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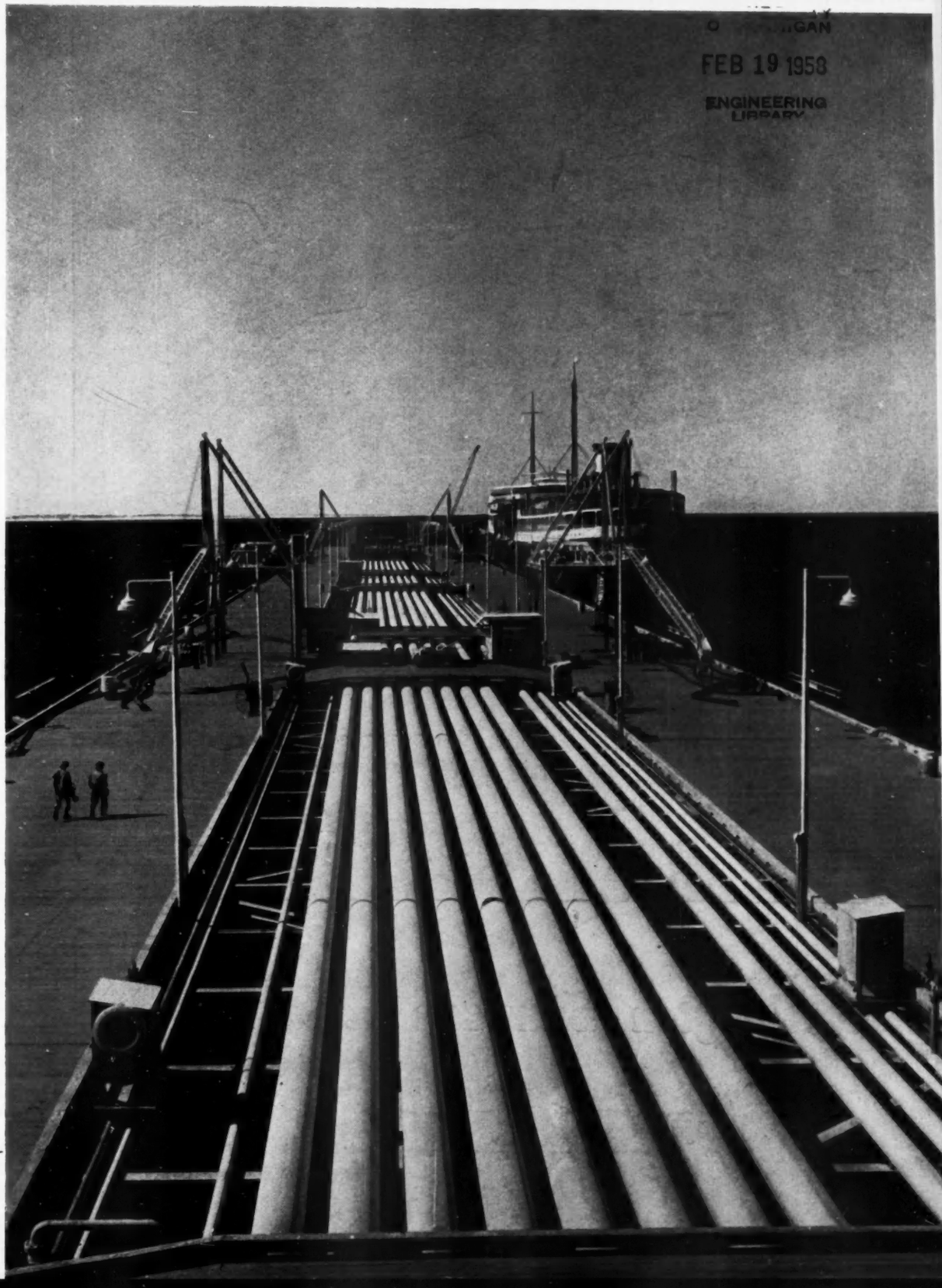

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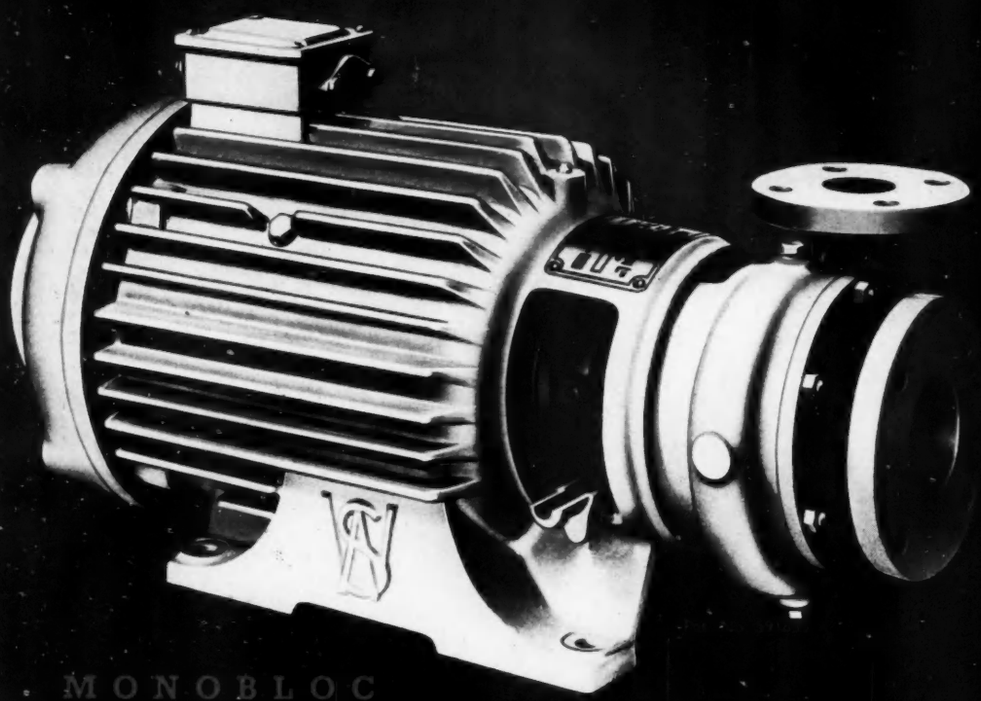

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ENGINEERING

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Decision Without Data

WHEN any major engineering project is put in hand, it can be fairly certain that before it is finished some men will be permanently injured or even killed. Indeed, the odds might reasonably be calculated for any particular case on the basis of past experience. Men's lives may well depend on single decisions, as when a year or so ago in the Italian Dolomites the construction of a dam had been delayed for various reasons, and it was decided to work later into the winter than was the usual practice. As a result, an engineer and two artisans were buried in an avalanche. It is not to be concluded that the decision was necessarily wrong, given the situation as it was known, but that such decisions cannot be made in economic terms alone. Thus, to the kinds of decision that the engineer must make—technical, commercial, and aesthetic—is added yet another—a moral one.

Moral problems concern a man's relationship with his fellows, and perhaps with his God; they follow from his sense of values and are therefore unique, subjective and incommunicable. To a stranger the accident in the Dolomites would mean little more than a paragraph in a newspaper, forgotten with the turn of a page; to the company concerned it would be a calculated risk justified by the great benefits that completion of the project would bring to many thousands of people; but to the wives of the dead men, the entire revenues of the undertaking would not be adequate compensation.

Matters of life and death are by no means the only moral problems engineers are called upon to resolve in the course of their work, though safety is a question that highlights the moral aspect of engineering activity. How much, for example, is it reasonable for a firm to spend on safety measures? The answer is such a personal one that no amount of rational argument could settle it. It is curious how many company directors defend their expenditure on press guards, goggles and safety boots on purely economic grounds (" we can't afford to lose man-hours through accidents"), when they are at least partly influenced by a genuine regard for their employees. No doubt fair dealing and good human relations bring financial rewards, as the Quakers and later Robert Owen demonstrated, but there can be no real correlation between virtue and profit. As Archbishop Whately said: " Honesty is the best policy; but who is governed by that maxim is not an honest man."

Yet only economics can provide an impersonal and objective standard for practical activities. And indeed the price mechanism can be regarded as a means by which a myriad personal valuations, whether they be moral, aesthetic or acquisitive, can be channelled into a workable and fruitful process. But from a moral standpoint it is an imperfect solution, unless it be assumed that moral fibre and financial success have a linear relationship.

However difficult it may be to establish criteria for decisions of this kind, a working compromise can usually be discovered. We should not abandon an engineering project because of the danger involved (though we should take sensible precautions) any more than we should cease to travel by train because one passenger in thirty million is killed in an accident. Safety measures may only be extended until their incremental cost becomes prohibitive. Thus it would be safer if the speed limit on British roads were 10 m.p.h., but the cost of such a limitation would be insupportable; so a line has to be drawn at a more plausible figure, such as 30 or 40 m.p.h.

In this respect the engineer is more like a military commander than a railway passenger; his decisions involve the safety of others. He can shed his responsibility by paying danger money where risk is involved and allow potential employees to balance their economic appetites against their fear of danger, so that the responsibility is each man's own. But to adopt such a procedure may be merely to evade the issue, since only the engineer may know the extent of the danger. Nevertheless, any self-respecting man, employer or employee, must ultimately wish to be responsible for his own actions and safety. It follows that in a democracy, all men should be made fully aware of any situation in which they are involved, so that they can assume a well-informed responsibility.

In this country responsibility of the individual is a basic assumption. Thus in the B.B.C.'s " At Home and Abroad " last week, Dr. T. C. Carter, said that there was no threshold for radiation injury to living things; however small the quantity of radiation we received, we or our descendants might be affected, though of course the lower the radiation level the smaller the risk. Dependent though we may be as a nation on nuclear power, we have been given the information on which to base a decision. Yet the level of radiation which we shall choose as an acceptable hazard cannot be decided on purely scientific grounds, but on a subjective evaluation. It will be a decision without data.

Cover Picture. *At Mena-al-Ahmadi, Kuwait, eight 24-in. pipes carry crude oil along the pier to tankers, six of which can be loaded simultaneously. Half-a-million barrels of crudes can be dispatched daily from this one point.*

★ ★ ★

Plain Words

The mysterious initials " D.B.W." at the end of an article in the house journal of a well-known firm of medical suppliers are evidently those of an engineer. " The Doctor's Husband " the article is called; the wife is a doctor and the husband is an engineer.

I cannot think of a happier combination of professions for two spouses. When only one partner is engaged in work which makes continuous demands on time and energy, the other must sometimes be impatient. But here we have two people who are both committed to vocations which inevitably lead to occasional neglect of the family. Mutual understanding must surely grow more readily in this marriage than in most. If they ever have time for an exchange of gossip about medicine and engineering—after they have done their day's work and somehow attended to domestic and family affairs—there must be numerous overlapping areas of knowledge and experience. " D.B.W." confirms it. " The engineering and medical professions," he says, " are remarkably similar; both are based on science, yet no practitioner, unless working in a research laboratory, is likely to spend more than 10 per cent. of his time upon anything to do with the science on which the profession is based. Indeed, it is regrettably noticeable that many of the most eminent men in both professions are entirely unscientific in their methods and outlook; and common sense is the great god at whose altar they worship."

He sets about giving the medical profession some of his applied common sense. He asks, not unreasonably, why the medical journals do not publish, along with " the exalted studies," detailed studies by trained sufferers of the maladies that really matter? Engineers would like to have machines which could report their faults and ailments. A gas-turbine which could say, " I am sure one of my blades in the first turbine stage is going to faint," would save an awful lot of trouble. In the cause of medical science, " D.B.W." reports his findings on the use of ascorbic acid in the treatment of the common cold; the value of Minuswy in cases of fibrositis; and (common-sense touch) the superiority of " the ordinary common or garden stinging-nettle " for getting rid of lumbago. Other lay sufferers of these troubles may profit from his findings, but I cannot imagine doctors taking him very seriously. The only time I had the temerity to suggest to a doctor that the cause of an illness was not what he thought it was, he turned to me with a knowing smile a little later and told me how to get rid of a squeak in the water pump of my car. " D.B.W." does not say whether his wife approved his article for press. She was probably too busy trying to mend the vacuum cleaner.

CAPRICORN

Weekly Survey

Wider Scope for Colonial Development

The scope of the Colonial Development Corporation will be increased if the Overseas Resources Development policy which was published just before Christmas becomes law. Under this bill the C.D.C. may borrow, other than temporarily, and have outstanding at any one time a total of £150 million compared with the present £100 million limit. In addition, the amount which the Secretary of State may advance to the Corporation is increased from £100 million to £130 million outstanding at any one time.

The C.D.C. will also be able to take on the role of managing agents and perform advisory functions in non-colonial Commonwealth countries. This last provision will enable the Corporation to operate once more in Ghana. The precedent is thus set for the Corporation to fulfil management functions and to advise on technical matters in countries of dominion status.

The advantages of operating as a management agent are that it offers one technique of spreading scarce but good managerial ability over as many projects in as wide a geographical area as possible. It enables an area to bid for managerial ability, which is scarce the world over, without applicants feeling that they are isolating themselves from modern developments and the prestige which attaches to managerial work in more advanced countries. The same is true of technical men. It will be easier to persuade technicians to work for a short period of time in tropical areas if their posts are made secure by belonging to an organisation with its roots in the United Kingdom.

The technique of the management agent has been tried out over many years, especially in India, with some success. It lends itself more readily to quick application in training than in industry but even in the latter the record of management agencies is good where they have been able to get good men and keep them.

India's Planning Problems

The one thing that seems to be certain about five-year plans is that one is never enough. This is certainly to be the case in India where the first five-year plan for economic development, although sustained by help from the West and the U.S.S.R., is being retarded by a shortage of foreign exchange. A second five-year plan has already had to be deferred. New licences for capital goods are being held up and the spending of foreign currency is being limited to raw materials and essential replacements and spares for machinery. Fears that state ownership might be extended throughout the economy have discouraged foreign investors and the Government has been doing its best to make it clear that state action will only be at a high level during the period while the country is being developed. Although private investors still fight shy of putting money into India, the World Bank has made a loan worth 90 million dols. for railway equipment imports in 1957 and 1958. The Bank has also joined the North American banks in a loan to the Tata Iron and Steel Company. The Canadian Government have contributed 15 million dols. under the Colombo Plan. In the ten years since independence, United States aid to India totals 1,000 million dols. The sterling balances are being run down to a level of Rs. 850 million which means a considerable reduction in the foreign security, but not gold, backing for the rupee.

India as a neutral power is prepared to accept help from behind the Iron Curtain. An agreement was recently made for a Soviet credit of Rs. 620 million (£46½ million) offered in 1956 to be applied to the construction of heavy machinery, mining machinery, coalfield development, a thermal power plant and an optical glass factory. These credits will be repaid in 12 equal instalments with interest of 2½ per cent. Tractors, Diesel generators and other machines are to be imported from Czechoslovakia against payment in rupees, with unused balances convertible on demand into sterling.

Australian Industry Looks Out

British industry is apt to think of Australian competition as an unfortunate but inevitable complication for the selling of British goods in the Australian market. It tends to be fairly philosophical about it as a long-term trend and highly critical of official economic policy which operates on the whole to boost local industrial output despite high costs of production.

The latest *Survey of Manufacturing Activity in Australia*, issued in October, 1957, and covering the previous six months, had this comment to make among others: " over a wide range of industry, manufacturers were able to counter cost increases with increased efficiency and improved productivity." The Minister of Trade, Mr. McEwen said last month, when commenting on the release of the six-month survey, that increased output had been achieved without increased employment thus indicating improved productivity.

When the Australian Government made a trade agreement with Japan last year it became apparent that imperial preference was going to be of limited duration for British industry in the Australian market. It is indeed only a question of time before imperial preference fades out completely there.

British industry may assume that preferential tariffs for British goods are not generally considered good business in that Dominion, and that supplies will be welcomed from other European countries. In capital equipment, for instance, Australians are becoming interested in Continental design, price and after-sales service. A further pointer for the future is the remark in the *Quarterly Survey* of the Australian and New Zealand Bank Limited which has commented favourably upon the idea that Australian exports may benefit in the long run from the European Common Market and the Free Trade Area. Australian industry is beginning to think of world markets.

Nigerian Prospect

Nigeria's development plans for the period 1955 to 1960 are discussed in some detail in the report *Overseas Economic Surveys: Nigeria* (H.M.S.O., 10*s*.). Altogether public capital investment in Nigeria during this period is likely to be something over £285 million. Of this total £92 million will be spent by the Federal Government and the remainder by the Regional Governments. The Federal Government intends to devote 56 per cent. of its expenditure to " the development of communications in the widest sense of the term." For example, it will make a loan of over £10 million to the Nigerian Railways Corporation, and will spend on its own account £10·2 million on ports and inland waterways and £14·4 million on telecommunications. The Regional Governments will, as might be expected, channel a good deal of their capital expenditure into education, and sums ranging from 18 per cent. to 33 per cent. of capital expenditure will be used by the regions for this purpose.

If all the schemes go forward as planned, British manufacturers should stand to gain a good deal. Nigeria is a good customer of the United Kingdom and 61 per cent. of the country's imports come from Britain. In particular, there has been a steady demand for machinery and transport equipment over the last few years,

although there was a slight fall in Nigerian imports of these items in 1957 compared with 1956. However, this was due mainly to the fall in commodity prices, which affected Nigeria's purchasing power: 70 per cent. of Nigeria's exports are accounted for by cacao, oil-palm products, ground nuts and cotton, all of which have experienced a fall in price over the past year. Nigeria also sends a considerable amount of tin abroad, and in 1957 felt the effects of the general decline in non-ferrous metal prices. Indeed, a long period of low commodity prices may mean that Nigeria will have to spend less on development.

Nigeria is fully alive to this and, partly to offset any decline in available funds from foreign earnings, has made vigorous attempts recently to attract foreign investment. Regional Government leaders have been visiting the western world in an attempt to attract private investment. Mr. J. V. Nwodo, East Region Minister of Commerce, visited London in November, 1957, while Chief C. D. Akran, Minister of Development in the West Region Government, made an extensive tour late last year of the United States, Canada, and the United Kingdom for the same purpose. Chief Akran has gained some success in Israel where it was announced in October that a mixed Israel-Nigerian construction company will be formed to operate in Nigeria with Israel investing a high proportion of the capital.

Power for Uganda

Uganda will be facing an acute shortage of electric power by 1965 according to an Economist Intelligence Unit survey. The future prosperity of Uganda depends to a very large extent on the development of the water power resources of the Nile and the widest possible distribution of electricity throughout the Protectorate. The present power lines are based on the Owen Falls dam and power station which started generating in 1954. Four of the ten generators provided for have still to be installed. Distribution is confined to the Masaka-Kampala-Jinja-Mbale strip bordering on Lake Victoria. The survey states that the industrial developments most likely to take place will be in industries relying most heavily on electricity. The biggest users are expected to be Kilembe copper, Nyanza textiles and Uganda Cement Industries.

The forecast in the survey is borne out by the 1956 figures for electricity supply and consumption in Uganda which have just been published. The Uganda Electricity Board generated 149·4 million units last year compared with 94·9 million in 1955. Consumption figures are distorted somewhat by the fact that the copper smelter at the Kilembe Mines at Jinja increased its consumption by 26 million units. Even without Kilembe, however, consumption for Uganda was 30 per cent. up on the year.

The bulk supply of electricity to Kenya over the 320 mile long power line from Owen Falls to Nairobi was inaugurated on January 1. By 1965 Uganda and Kenya between them will be taking all the electricity Owen Falls can supply and then asking for more. Big as Owen Falls is by African standards, it is probably not big enough. The survey states that the level of demand will justify a second dam on the Nile.

Opportunities in Iran

Since the fall of Dr. Mossadeq, Iran has been a good market for United Kingdom exporters, and present indications are that trade between this country and Iran will expand at a growing rate in the future. In 1953, United Kingdom exports to Iran totalled only £4·6 million, compared with around £30 million a year before the oil dispute. This had recovered by 1956 to nearly £26 million, of which engineering exports formed a sizeable proportion. Machinery other than electrical equipment accounted for 23 per cent. of Iranian imports from the United Kingdom, while imports of electrical machinery from this country amounted to 8½ per cent. and imports of road vehicles and aircraft to 15 per cent. of the total. A new edition of *Economic and Commercial Conditions in Iran* (*Overseas Economic Surveys: Iran*, H.M.S.O. 5*s*.), prepared by H.M. Counsellor (Economic) of the British Embassy, Teheran, indicates that Iran offers excellent opportunities to U.K. companies prepared to make efforts to cultivate this market.

Heavy engineering companies, for instance, stand to gain a good deal from the seven-year plan which was initiated in 1949 and is now in its second period. For this second stage the official development organisation is authorised to spend 350 million dols. with a high proportion of expenditure going to such projects as roads, railways, harbours, airfields, irrigation, municipal water and electricity supplies. For this reason, there is an immediate and growing demand for all kinds of contractors' plant and equipment. So far, considerable use has been made of British skills in the construction of communications and factories. British firms have been appointed as consulting engineers for the building of 2,500 km. of roads, for the development of six airfields, including extensive improvements at Teheran, and for the building of cement factories and silos.

The survey points out that British manufacturers can take fuller advantage of the opportunities offered in Iran by setting up plants in that country in partnership with Iranian concerns. Until now insecurity, combined with Iran's exposed situation, has discouraged foreign investment. The situation is however changing and of recent years there has been a trend towards greater stability in Iran. Persia appears to have gained at last a strong and stable government. Economically, the drain on foreign reserves which followed the oil crisis has now been halted, and successive devaluations are no longer typical of the Persian economy. Partnership, however, need not involve heavy capital investment. The provision of "know-how," as many British consulting engineers have discovered, is considered just as important a factor.

Crisis for the F.T.A.?

There was a time when Britain's adherence to the idea of a Free Trade Area had a faint flavour of condescension about it. There are increasing signs that such an attitude is now something more than a luxury. Now that the European Economic Community has been formally established by the ratification of the Treaty of Rome it is becoming increasingly appreciated in this country that the European Common Market without the Free Trade Area attached to it is a serious threat to this country's competitive position in export markets. The Free Trade Area is becoming increasingly a necessity for the United Kingdom as the Continental market opens up for industries established within the six countries comprising the European Economic Community.

In Paris last week it was becoming increasingly apparent that the British proposals on how to deal with agriculture are highly unpopular in certain countries within the Community and that the French are increasingly in favour of substituting the idea of a wider European Common Market for the British idea of a Free Trade Area. The French probably consider that they are in a good bargaining position. They have the disadvantage that they are faced with the need to adjust their own economy to the requirements of the European Economic Community but that is a small consolation to the British who are on the outside—and the French know it. They may yet be in a position to exact a high price for accepting the idea of the Free Trade Area. Probably the only influence now moderating the French attitude is the need to pursue a common policy towards the Free Trade Area (at least to some extent) with other members of the E.C.M., two of which (Western Germany and Holland) are known to be favourable to the F.T.A. idea.

Letters to the Editor

MOTION OF A YACHT

SIR, I have read Mr. W. A. Crago's article "The Motion of a Yacht Through Air and Water" with interest. Frankly, I think he has said a lot without telling us anything. I should think most engineers hardly know the difference between "round bilge" and "hard chine," Fig. 7. His diagrammatic view showing leeway in Fig. 6 is horribly out of proportion, and I hope that in any boats I have L_H and S are more or less opposite, so that practically no rudder is required at all. The same applies to Fig. 4.

Yachting papers have told us a lot more about the effects of "heel" and their diagrams showing the forces creating the forward motion of a vessel close hauled are much simpler to understand. The vessel would not move forward with an apparent direction of wind, as shown in Figs. 2 and 3, and what is more, there would be a tremendous lot of flutter in the luff. The picture in Fig. 8, showing a catamaran with one hull out of the water, is amazing but quite impracticable. It is interesting to note, however, that the rudder of the hull out of the water is square fore and aft although the vessel is travelling forward nicely.

In my view, Mr. Crago has tried to cover far too much in a comparatively short article. Plywood dinghies and a vessel like Sceptre can hardly be satisfactorily compared in a single article.

Yours very truly,

H. DICK BROOM.

Broom and Wade, Limited,
Bellfield Works,
High Wycombe,
Buckinghamshire.
January 13, 1958.

Editor's Note: Another letter on this subject appeared in our issue of January 17, page 68. Mr. Crago's article was published on page 6 of our issue of January 3.

A GEAR TRAIN WITH NO BACKLASH

SIR, The tests of a high-performance gearbox described on page 69 of ENGINEERING for January 17 are interesting, but experience shows that results of tests taken on part of a gear train, combined with assumptions or estimates of the performance of the remainder, may be misleading. The results shown in Fig. 3 would have been more realistic, and would probably show a rather different natural frequency if the stiffness tests had been taken on the complete mounting, locked at the training rack.

The same applies to backlash: it is possible to eliminate this from a self-contained gearbox, while an overall test of a complete gear train, such as is shown in Fig. 2, will give different results.

Yours faithfully,

HUGH CLAUSEN.

17 Harman-drive,
London, N.W.2.
January 20, 1958.

COOLING TOWER PACKINGS

SIR, There are many points in Mr. E. A. Howe's letter, published on page 804 of your issue of December 27, with which I disagree, but, as the correspondence has already continued for some time, I am confining myself to the major issues.

Sometimes when several letters are written on the same subject previous points made are forgotten, and I feel that this is the case with Mr. Howe's comments regarding timber treatment for packings. My original point was that to make a film type packing economical it was necessary that the timber should be of thin cross section. This was because more timber was required and the fabrication costs were

greater for film packing than for splash packing.

The report to which I referred is applicable to cooling tower packings in general, and I repeat my point that this report stated that in effect deterioration is inversely proportional to the thickness of the members. Truly the timber treatment firms have revised the formulae of their chemical preparations and are specifying higher concentrations. Time has not been sufficient, however, for it to be proved that this is the complete answer.

In my previous letter (ENGINEERING, November 29, page 676), I stated that considerable trouble has been encountered in the United States with film type packings and this does not depend on the design of the packing so much as the thickness of the members, which are similar to those in this country.

It may be possible, of course, to assume the state of the packing in the centre of a section from looking at the top and the bottom, but nevertheless, if a fault occurs in the centre, it is expensive to correct. Splash packing is made in easy-to-handle sections, and experience, both in this country and abroad, demonstrates that throughout its life the packing can be easily removed and the tower thoroughly inspected. In fact, it is usual for annual inspections to be made of the complete tower to ensure that it is operating continuously on the highest possible efficiency. This, unfortunately, cannot be easily done with a film type packing.

Mr. Howe's point 2, in his letter above referred to, misses completely the fact that extended-surface packing cannot operate under the same high water loadings as are suitable for splash packed towers.

I gave in my previous letter the approximate savings in cost which could be made when altering the " approach " for a specific cooling tower duty. This was given as a guide and as part of my reasoning for full technical consideration of the *complete* cooling system required by the client. I did not specify the actual range covered but obviously such a saving would indicate that the range would be small. Mr. Howe makes his point by considering a fairly large range. His statement in no way contradicts mine; in fact, it is only another expression of the same effect. Both statements emphasise that a complete investigation of the cooling system should be made, bearing in mind that a small increase of the " approach " can result in an appreciable saving in cost.

Yours faithfully,

DEREK J. TOW.

53 Tytherton-road,
Tufnell Park,
London, N.19.
January 6, 1958.

BALANCE OF MIGRATION

For a country dependent as we are on skilled manpower we are strangely casual about the records we keep of those who leave or land on our shores. The latest report (*Third Report of the Oversea Migration Board*, December, 1957, Cmd. 336) of the Oversea Migration Board again draws attention to the inadequacy of the statistics on migration. It is extraordinary in this day and age that no figures are kept of the numbers of emigrants and immigrants who travel by air; and, in view of our own shortage of scientific and technical manpower, it is surprising that no attempt is made to separate in the statistics those who fall into this category. From figures given by the Advisory Council on Scientific Policy and quoted in our editorial of last November 22, it appears as if something over 8 per cent. of the numbers of professional engineers qualifying every year are going abroad. The reasons for this emigration are complicated and it is good to learn from the Board's report that the possibility is being studied of an inquiry by the Social Survey into the characteristics of United Kingdom emigration, with particular reference to professional and skilled workers.

On overall figures the report is re-assuring; the net movement of migrants is small, averaging an annual loss of about 20,000 a year. Of the emigrants, the vast majority of whom went to the five older Commonwealth countries, only about 75,000 or a half of the total, had been in employment and, of these, 17·7 per cent. of the men came from the engineering and metal industries. This is a considerably lower proportion than in the employed population at home; but it is to be expected that more of them would have been skilled. Of the immigrants, rather less than a quarter were coloured, most of them unskilled or semi-skilled.

The effects of temporary changes in the domestic scene on the rate of emigration are demonstrated by the contrast between 1955, a year of great activity and unfilled vacancies at home, when emigration almost reached its lowest post-war level and 1956, when the credit squeeze and, later, the Suez crisis, led to a feeling of uncertainty and lent a stimulus to emigration. This change continued in the first half of 1957, during which Canada admitted 72,000 immigrants from the United Kingdom and the total emigration probably reached 220,000. It will be interesting to see whether this trend is once again reversed now that economic conditions on the other side of the Atlantic have deteriorated.

The report admits that on balance we are losing more skilled and professional workers than we gain, although it points out that a number of such workers come to this country from the Commonwealth. The question is whether this net loss is of advantage or otherwise to our economy and whether any measures are needed to counteract it. There are many people who hold the view that, on political grounds, it is desirable to encourage the emigration to Commonwealth countries of some of our best young people and the political and economic benefits of such a policy cannot be denied.

Unfortunately, our own resources are severely stretched and we are spending large sums of money to expand them through the universities and technical colleges. In the same way as the advantages of overseas investment must be realistically appraised by comparison with the returns to our economy of industrial change and expansion at home, with which it must compete, so must the advantages of having British engineers in positions of authority abroad be set against the handicaps which their absence may create for our exporting industries.

In practice there may be little specific that we can do about these movements, except to make sure that salary scales for professional engineers are adequate and that young men are given as much opportunity and responsibility as they can take as early as possible in their careers.

On the whole, the picture does not appear to be as black as it has sometimes been painted, particularly during the period of the much publicised queues at Canada House last year. An active and progressive industry, expanding opportunities for scientific and technological research and development and the maximum freedom to publish results and exchange ideas will probably always provide the best attractions for engineers and scientists of ability.

SIEMENS-MARTIN CENTENARY

The Iron and Steel Institute has decided to celebrate the centenary of the Siemens-Martin process in 1963. At the Autumn general meeting of the Institute, the President stated that while the first practical application of the regenerative furnace to the melting and reheating of steel had been made by William Siemens in 1857, the operative year for the steel industry should be 1863, when Pierre Martin had taken out a licence, and he and his son, Emile, had smelted steel in a small open-hearth furnace at Sireuil, near Angoulême, France.

Plant and Equipment

CENTRALISED LUBRICATION

Shown in the accompanying illustration is a small economical lubricator, the Centralube Multiminor, for centralised lubrication with grease or oil. The lubricator is made and marketed by Centralube Limited, Great Western Trading Estate, Park Royal-road, London, N.W.10.

The Centralube Multiminor can lubricate one to eight points with one downward stroke of the operating lever. Each lubricating point is at a different level, and each is fed in turn by the internal piston, which cannot feed lubricant to an outlet until the discharge of lubricant to

the previous outlet has been completed—that is, all outlets receive the same amount of lubricant, irrespective of whether the bearings they are supplying are tight or loose. A de-aerating screw provides for de-aerating the grease and avoiding airlocks; it also serves as a locking bracket for the lever during periods of rest.

The container holds 9 oz. of grease or $\frac{3}{4}$ pint of oil. The output per point for each lever movement is 0·4 grams. Non-fibrous grease of the consistency of A.S.T.M. 280 or over should be used. The maximum permissible length of pipelines, when using grease, is 25 to 30 ft. of $\frac{5}{16}$ in. outside diameter, 24 or 22 s.w.g. piping; or 10 to 12 ft. of $\frac{1}{4}$ in. diameter, 24 or 22 s.w.g. piping. For oil, these lengths can be multiplied four times.

AUTOMATIC-CYCLE FORM GRINDER

A modified version of their model 1012 crush-form precision grinder, having a fully-automatic cycle, is announced by A. A. Jones and Shipman Limited, Narborough-road South, Leicester. It is arranged with power driven vertical wheel feed and rapid return and hydraulic table traverse with infinitely-variable speeds up to 80 ft. per minute. Hand cross-feed is provided for setting purposes.

When the machine is switched to automatic operation, and the " start " button is pressed, the table moves from its run-out position to bring the workpiece under the wheel, and then operates reversals to a stroke length as set by the reversing dogs. The feed handwheel rotates for a downwards feed, the minimum rate of which is approximately 0·075 in. per minute, or 0·0006 in. per stroke at 120 strokes per minute; the maximum rate is 3 in. per minute. At a pre-determined point in the total depth of feed of approximately 0·22 in., the automatic cycle is broken, the feed reverses rapidly to its upper limit of travel, and the table traverses out to the left and stops. Provision is made for hand and semi-automatic operation during setting.

OBSERVING DANGEROUS PROCESSES BY TELEVISION

Remote Control of Nitro-Glycerine Production

The production of nitro-glycerine by the Biazzi process is susceptible to remote control. At the Ardeer factory of the I.C.I. Nobel Division a Biazzi plant has recently been installed and, after a trial period of direct operation, the plant has now been adapted for remote control. A full description of the plant was published in ENGINEERING, vol. 182, page 73 (1956). The remote control room is shown in Fig. 1; overall indication of the operation is provided and the processman effects control from the desk. The room is situated in a concrete building at some distance and protected from the nitrating room.

Television cameras are used to observe the process vessels in the nitrating room through a long window, as can be seen in Fig. 2. No men are required to be present. The cameras scan the room and relay visual information by closed circuit to the remote control room, where two small television screens have been installed on the main instrument panel. Besides the television link, the sounds of the operation can be heard by means of microphones and an internal communication system. The sensation of direct control is thus closely simulated.

For a period the plant was operated from a control desk situated in the nitrating building. In this way processmen became familiar with the plant and its method of control; subsequently, desk and instrument panel were removed to the protected building. In special circumstances during testing and preparation for the start-up of nitration, instructions can be passed between a processman in the nitrating room and his companions in the remote control room.

Fig. 1 At the I.C.I. Ardeer factory the Biazzi plant for producing nitro-glycerine has been adapted for remote control. A control desk and an instrument panel equipped with two small television screens are installed in a concrete building separate from the process plant.

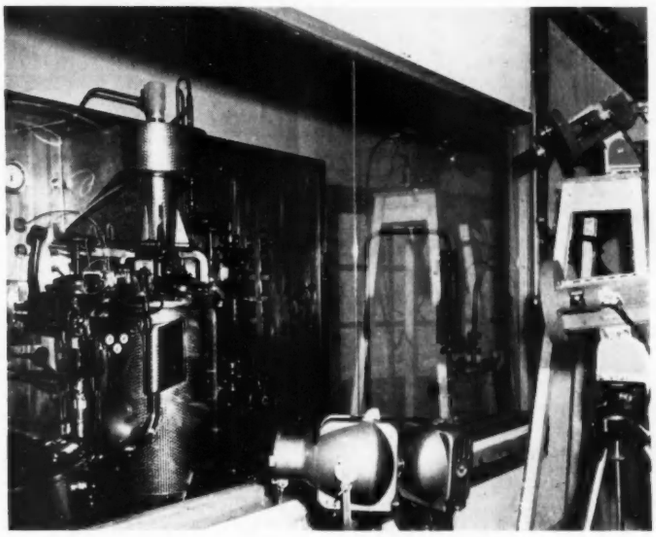


Fig. 2 The Biazzi nitrating plant is viewed through a window by television cameras transmitting through a closed circuit to the protected control room. Microphones enable the sounds of the process to be heard by way of an internal communication system.

SOLID FLOW DETECTOR

It is often necessary to know, in a conveyor system carrying solids, when the flow fails due to obstruction or to lack of material. A device for detecting a stoppage has been produced by Bailey Meters and Controls Limited, Purley-way, Croydon, Surrey, which causes little obstruction to the flow, and is easily installed in any pipeline.

In principle, the device consists of a probe inserted into the pipe, over which the solid material passes, and which transmits the vibrations caused by the passing to a pick-up outside the pipe. The pick-up output is then amplified and fed to an indicator or warning system as required. The device was originally produced for use with the transport of coal and has proved satisfactory for those sizes normally used in power stations. The smaller the particle size, however, the smaller the signal produced from the probe, and the greater the amplification that is required. It is expected that the probe could be used equally effectively with materials other than coal.

The probe itself consists of a length of mild steel bar, 1¾ in. in diameter, which projects into the conveyor pipe about ½ in. The bar is held in the centre of a mild steel sleeve by a layer of tough rubber, and the sleeve is bolted on to the fixing flange, which is itself bolted to the pipe. It is thus possible to remove the probe unit for inspection without emptying the pipe or stopping the flow. The vibration pick-up is fixed on the external end of the probe. The standard amplifier unit is of the four-stage design using junction transistors. It is temperature stabilised up to at least 50 deg. C. Printed circuit techniques are followed with all components mounted on the laminate.

The passage of solids through a pipe can be detected by a probe sensitive to vibration. Cessation of signals can be used to operate a warning device.

A relay stage included in the amplifier incorporates a time delay so that the warning device is not operated due to a momentary stoppage of the coal passing over the probe. This delay can be adjusted to a required value by the addition of further condensers in parallel in the amplifier unit, giving a value up to 25 sec. For greater delays than this, a supplementary unit can be used. A typical example of an installation requiring a delay time is where the feed to a pulverising mill is controlled by a feeder table operating on the on/off system, with the result that the coal flow down the pipe is intermittent. The amplifier can be located in any convenient position not exceeding 200 ft. from the probe, the connection being by a co-axial cable. A short run is an advantage as there is then less attenuation of the signal.

While the amplifier can operate up to 50 deg. C., the maximum operating temperature of the probe is determined by the pick-up attached to it, and the temperature of this must not exceed 100 deg. C. The relay incorporated in the amplifier unit is capable of switching about 20 watts, at 230 volts a.c., and will therefore operate a normal 15 watt pigmy alarm light. Where the alarm signal consumes more than 20 watts, as might be the case with a heavy-duty bell or klaxon, an external relay may be required in addition. If very fine coal is passing down the pipe it may be necessary to use an extended probe which reaches 6 in. into the normal 18 in. diameter pipe. The probe should naturally be so situated that the alarm is given in time to make necessary correcting action.

Continuing **Plant and Equipment**

TENSIONING CONVEYOR BELTS

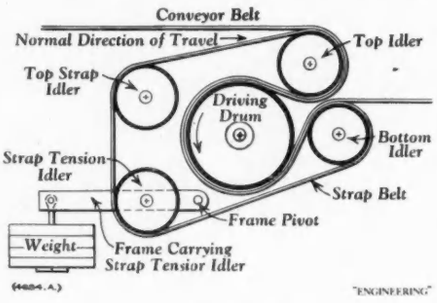


Fig. 1

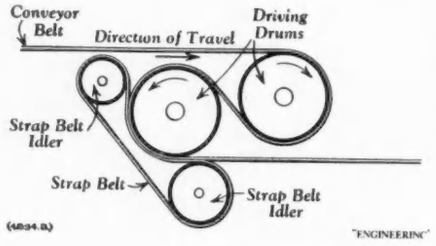


Fig. 2

Driving tension for a conveyor belt is provided in the Baker device by a separate tension belt. No more tension is applied to the main belt than is necessary to prevent sagging.

The pressure between the belt and the driving drum necessary to ensure that a belt conveyor is driven without slip is usually provided by giving the belt itself an initial tension. A method of providing the necessary driving friction devised by Mr. R. G. Baker, deputy chairman, North Eastern Division, National Coal Board, obviates the need for such tension in the conveyor belt; as a result, a greater tractive force can be applied to a belt of given size, or a belt of lower strength may be used for a particular load.

With the new method a short auxiliary belt is provided, in contact with all or part of the outer surface of the conveyor belt as it passes round the driving drum or drums. The tension in the auxiliary belt is adjusted so that it holds the conveyor belt against the drum with sufficient friction to ensure drive without slip. It is only necessary to provide sufficient tension in the conveyor belt to prevent it from sagging unduly between the return idler rollers. This can conveniently be done by means of a light gravity arrangement in the normal loop take-up.

Two typical applications of the system are shown in the accompanying drawing. In Fig. 1 it is applied to a standard single-drum conveyor drive gear. The conveyor belt passes in the usual way over an idler, round the drum, and then over another idler. The auxiliary or strap belt also passes over the same idler in such a way that it is on the outside of the conveyor belt when it runs round the driving drum. Two further idlers are used with the strap belt, and one of these is carried by a pivoted, weighted frame. Tension in the strap belt is adjusted by means of this weighted idler, to give the necessary driving pressure.

In Fig. 2 the strap belt is shown adapted for use with a two-drum driving gear. As the drawing shows, the strap belt in this case is brought into contact with the back of the conveyor belt for part of its travel over one of the driving drums. The means of tensioning the strap belt is not shown in Fig. 2, but it can be of any convenient type. Similarly, the gravity take-up arrangements to provide the necessary light tension on the conveyor belt, which are also not shown, can be of any suitable pattern.

SMALL-FLOW VALVE

The Crosby Valve and Engineering Company, Limited, Wembley, Middlesex, are now manufacturing the Masoneilan type 107/108 diaphragm operated control valve which is designed for regulating very small flows, as in pilot plants and dosing applications. It is rated at 6,000 lb. per sq. in. with a half-inch connection screwed for either BSP or API. The minimum trim available has a flow coefficient of 0·07. This can be supplied in stainless steel or Stellite, with a needle type plug giving linear flow characteristics. It can be used for pressure drops up to 5,000 lb. per sq. in. The diaphragm is designed for operating at air pressures between 3 and 15 lb. per sq. in., and is housed in an aluminium alloy structure for lightness. The overall height of the valve is less than 11 in. and the weight is 15 lb.

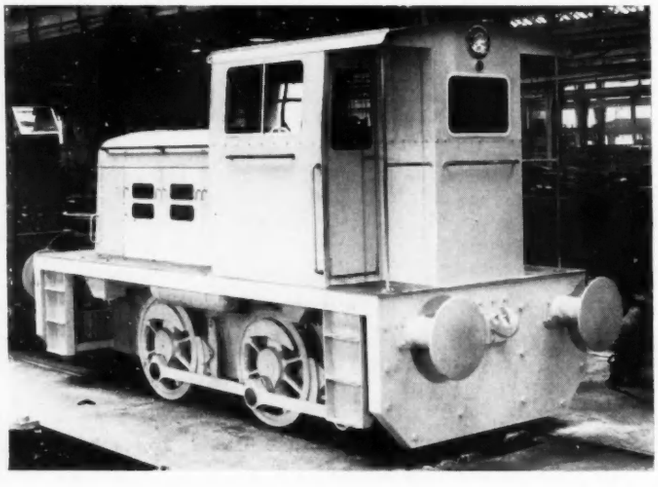
DIESEL SHUNTING LOCOMOTIVE *Good Visibility for the Driver*

The first unit of a new range of Diesel shunting locomotives which will have horsepowers varying between 176 and 220, has now been constructed by John Fowler and Company (Leeds), Limited, Hunslet, Leeds 10, and has recently undergone tests on the company's proving ground. The new range will be available in both the 0-4-0 and 0-6-0 wheel arrangement for a variety of rail gauges and also for flame-proof conditions.

The first unit has the 0-4-0 arrangement and is rated at 176 b.h.p. The weight in working order is 28 tons and the wheelbase is 5 ft. 6 in., which enables it to negotiate curves down to 60 ft. quite easily and to run on rails down to 75 lb. per yard. With an overall height of 11 ft. 3 in. and an overall width of 8 ft. 5 in., it comes well within British Railways' L1 loading gauge. It is available in two forms, one of which has an adhesive weight/tractive effort ratio of 4·18 : 1 and the other of 3·8 : 1, the variation being in the final gearbox. The frame is built up of steel plates and rolled steel angles with steel-plate buffer beams at each end. Riveting or driven bolts have been used in assembly. Cast-steel axle boxes with gun-metal bushes and cast-iron keeps are used and are lubricated by oil boxes and spring oiler pads. The wheels, which are 3 ft. 6 in. in diameter, are made up from cast steel centres with rolled steel tyres. Laminated bearing springs are provided.

The driver's controls are duplicated on each side of the cab, a closed structure which has sliding windows and doors. The driver can see the buffers at both front and rear of the locomotive from his normal control positions, and can also reach his controls while leaning out of the side windows.

The sliding doors of the cab (one on each side, opening to the rear) are set forward from the buffer beam and the steps, forming small covered platforms on each side to accommodate a shunter. In this way the latter is offered some protection from the elements without crowding the driving space. Moreover, the use of a pneumatically-operated epicyclic gearbox simplifies the controls that the driver has to handle, and reduces them to four handles on the control panel: engine speed, Westinghouse brake, gear change, and forward/reverse drive. In addition there are a wheel for the screw parking brake and pedals for the sanding gear.



The first of a new range of Diesel shunting locomotives develops a tractive effort of 15,000 lb. at 3·5 m.p.h.

Power is supplied by a normally aspirated Leyland EN 900 V6 engine, which develops 176 b.h.p. at 1,500 r.p.m. This is a four-stroke six-cylinder engine of 5·5 in. bore by 6·5 in. stroke. The maximum torque of 658 ft. is developed at 1,000 r.p.m. By using a supercharged version, a locomotive of 220 b.h.p. can be produced, thus enabling an owner to have locomotives of substantially different power, while yet having to carry only a single range of spares. Starting is by twin electric motors.

Power from the engine is transmitted through a Fluidrive traction type coupling capable of transmitting the full torque at maximum r.p.m. with a slip of 2 per cent. A Hardy-Spicer needle roller cardan shaft leads to a Self-Changing Gear's SE4 four-speed pneumatically controlled compound epicyclic gearbox, having ratios of 4·08 : 1, 2·35 : 1, 1·49 : 1 and 1 : 1. This in turn leads to a final speed reduction forward/reverse gearbox which is also pneumatically operated. In the production models this will be made by Alfred Wiseman. The reverse gear is of the bevel wheel type and the final drive is by means of double reduction gear wheels to the jack shaft. With the exception of the latter, all shafts are mounted in ball or roller bearings.

In first gear the Mark I type has a maximum speed of 3·54 m.p.h. and exerts a tractive effort of 15,000 lb. at 80 per cent. efficiency. The Mark II version in the same gear has a forward speed of 3·2 m.p.h. and exerts a tractive effort of 16,500 lb., also at 80 per cent. efficiency. These figures are based on operation at sea level, and due allowance must be made for variations in altitude.

Special Article

B.O.A.C.'S FUTURE JET-LINER

The VC10 airliner will have transatlantic range capabilities.

THE VICKERS VC10

In May last year British Overseas Airways Corporation announced that they intended to order high-speed long-range jet airliners for use on their African, Australian and Far Eastern routes in the mid 1960's. The order has now been placed with Vickers-Armstrongs Aircraft Limited, for 35 VC10 aircraft—a £60 million contract, the largest airliner order ever placed in the United Kingdom; and B.O.A.C. have taken an option on a further 20.

Since the VC10 was first conceived, around four Rolls-Royce Conway by-pass turbojets, the Conway engine has been developed to higher powers (one version is now rated at 17,250 lb. and by the time the VC10 goes into service it will doubtless be higher). In conjunction with developments in the airframe design, this means that the VC10 will not only be suitable for operation on the Commonwealth routes, on which some of the airfields, situated at high altitude at high ambient temperatures, impose limitations on the type of aircraft which can be operated, but it will also have the range capabilities for non-stop North Atlantic flights—performance characteristics which have, in earlier generations of aircraft, been incompatible. The trans-oceanic Boeing and Douglas jet airliners that are due to come into operation in 1959-1960, for example, have not the take-off performance necessary for use on the Commonwealth and Far-Eastern routes. The cruising speed, something over 600 m.p.h., is also claimed to be faster than that of the American jet-liners.

It will be seen from the illustration above that, following the fashion set by the French in the Sud-Aviation Caravelle airliner, the Conway by-pass engines are pod-mounted at the aft end of the aircraft. Vickers-Armstrongs claim that this will be the first four-engine aircraft to adopt the rear-engine layout. A corollary to the engine layout is the considerable length of fuselage forward of the wing.

The advantages of the rear-engine layout are many. Immediately apparent is the " cleanliness " of the wing, unencumbered by nacelles or pod pylons, enabling the use of long-span trailing-edge flaps and leading-edge slots and affording structurally a simpler and more efficient proposition. The whole of the passenger cabin is forward of the engines, giving the maximum of vibration-free comfort and the minimum of engine noise. Difficulties of jet-efflux fatigue loading on the aircraft structure are eliminated. The external location of the engine pods facilitates servicing, and if, as the aircraft is " stretched," it becomes necessary to install developed engines which themselves may have grown in size, the modification problem is very much simpler than is the case when the engines are buried in the aircraft's wings.

It may be observed from the illustration that, in the VC10 layout, the intakes of the Conway engines are slightly above and behind the wing trailing edge. We understand that preliminary wind-tunnel tests have shown that this is likely to be the optimum location for the Conways and that, at high incidence, mutual benefit may be derived from the proximity of wings and inlets, which would possibly be one of the factors contributing to the high take-off performance required of the VC10. At present, " blown " flaps—the use of air bled from the engine compressors to increase the air circulation over the flaps—are not intended for the first mark of aircraft, but it is possible that later versions may be so fitted.

As is the case with the Vanguard airliner which Vickers-Armstrongs are currently constructing for British European Airways, the VC10 will have a " double-bubble " fuselage—the passenger cabin occupying the top deck, and the space below the cabin floor providing a very large hold for baggage and freight. The substantial freight capacity of the aircraft should add greatly to its flexibility and value to the operating company. The passenger capacity is 108 first-class, 135 " standard high-density " or 152 " extra high-density " seats. (For comparison, the Boeing 707 seats up to 180 people and the Douglas DC8 up to 171 in the " extra high-density " arrangements.) The current trend towards smaller cabin windows, more closely spaced, is evident from the illustration.

The first VC10 is expected to fly in the late summer of 1961, and B.O.A.C. are to receive a " fleet " of VC10's in 1963. If the aircraft lives up to its promised performance and delivery dates it is indeed, as B.O.A.C.'s managing director has said, " potentially a world beater."

THE BRISTOL 200 SHORT-HAUL AIRCRAFT

An even more unconventional engine layout than that of the VC10 has been favoured by the contestants for the British European Airways short-range jet-liner contract—the de Havilland Aircraft Company, Limited, and the Bristol/Hawker-Siddeley Group combination. De Havilland have not yet officially released an illustration of their project, but it is said to be very similar in layout to the Bristol 200, a model of which is illustrated below and which shows a three-engine layout, one pod mounted on either side of the rear fuselage and one on top of the fuselage.

There is the possibility that the Bristol/Hawker combination may go ahead with the Bristol 200 jet-liner, whether or not they secure B.E.A.'s order. They have already sent a sales and engineering team to the United States, at the invitation of a prominent American airline, to discuss plans for a fleet of Bristol 200 airliners.

Some details of the projected aircraft are now available: it will carry up to 100 passengers at a cruising speed of over 600 m.p.h. over ranges between 300 and 1,700 miles. It has a span of 91 ft., a length of 121 ft. 6 in., and an all-up weight of 120,000 lb. Any engine of suitable thrust rating can be installed, to the aircraft operators' requirements: for instance, if British European Airways do select the Bristol 200, the choice will be Rolls-Royce by-pass turbojets.

The fundamental design consideration in the Bristol 200, it is stated by Bristol, has been its exceptionally high power/weight ratio which enables the aircraft to climb at a speed only a little below its high sub-sonic cruising speed, and also makes possible the use of the smaller airfields usually associated with short-haul routes. The performance of the Bristol 200 on only one engine (33⅓ per cent. power) is, it is claimed, very much better than that of to-day's four-engined airliners on two (50 per cent. power).

Bristol/Hawker are offering the Bristol 200 airliner to overseas airlines.

Special Article

GETTING BRICKS FROM SAND FOR THE SHAIKH OF KUWAIT

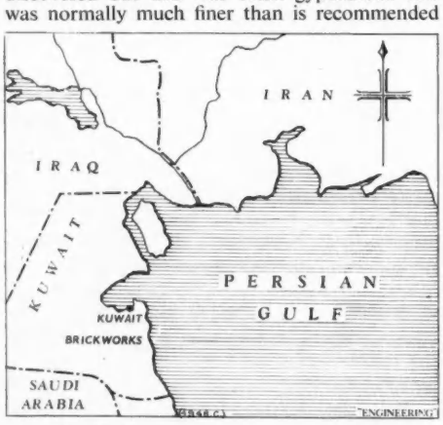
Planning a Fully Integrated Brick and Lime Plant Using Local Sand

The consulting engineer for the Kuwait Sand-Lime Brick Works was Mr. R. Fitzmaurice, M.I.C.E., M.Cons.E., of Cyprus, in his then capacity of scientific adviser to the Ruler of Kuwait. His senior assistant, working primarily in the United Kingdom, was Mr. G. G. Rice, who also made the detailed survey of the sand deposits in Kuwait on which the project is based. The detailed design and analytical work was undertaken by George Wimpey and Company, Limited, of London, under the direction of Dr. L. J. Murdock, A.M.I.C.E., assisted by Mr. R. N. Crooks. The Kuwait Public Works Department is under the presidency of H. E. Shaikh Fah'd Al-Salim Al-Subah. The following description of the project is the joint work of Mr. Fitzmaurice, Mr. Rice, Dr. Murdock and Mr. Crooks.

In 1951 the Ruler of Kuwait began making plans to increase the speed of social development in the Shaikhdom. Following great increases in oil production and therefore in oil royalties, new roads and harbours, schools and hospitals, houses and shops were planned as well as the complete re-development of the town of Kuwait. For this work building materials of all classes were necessary.

At that time, the Shaikhdom of Kuwait produced no building materials. Clay bricks were being imported from Iraq; cement and steel from various countries; timber from Europe and India. Only sand, gravel and a poor quality calcareous sandstone were to be found in the country.

During 1952, under the direction of Mr. R. Fitzmaurice, M.I.C.E., M.Cons.E., then the scientific adviser to the Ruler, a geological survey was undertaken to establish what raw materials for building purposes were available. Unlimited quantities of gravel were found but these were only surface deposits which were frequently contaminated with gypsum, that meant gathering the gravel by hand. Not surprisingly unlimited quantities of sand were discovered but this was often gypsiferous and was normally much finer than is recommended



The Shaikhdom of Kuwait, at the head of the Persian Gulf, has a population of 250,000, most of whom live in Kuwait town.

for building purposes. There was much impure gypsum but little likelihood of finding deposits which could be exploited by normal commercial methods for making plaster. Hardly any suitable building stone was found. There were thin seams of Miocene clay, mostly very impure, and some recent deposits of silty clay, a few inches thick, which has occasionally been used for small-scale clay brick-making, though with poor results. Quantities of calcareous mud and silt covered the sea bed and were also found on the islands in Kuwait Bay. These clays were highly saline and appeared unsuitable for either brick-making or cement manufacture. Altogether the prospects of local building materials production were not encouraging.

On analysis, however, it was found that many of the sands taken from the neighbourhood of the beaches were highly calcareous. This was due to the presence of shell fragments and unconsolidated oolites. It was realised that this sand provided the raw materials for sand-lime brick-making if the problems of making bricks from such an unusual raw material could be solved.

These and subsequent investigations are described below and, as it was shown to be a practical proposition to produce excellent bricks by the methods evolved, a decision was taken early in 1953 by the Government of Kuwait to proceed with the construction of a sand-lime brick plant to produce about 40 million bricks a year. The first stage of the plant, making bricks with imported lime, came into production in the autumn of 1955. Lime was being produced locally by the autumn of 1956, and, from the beginning of 1957 onwards, bricks have been made entirely from indigenous materials.

So far as is known this is the only sand-lime brick plant with its own lime-production unit integrated as part of the manufacturing process, that is, with all the plant on one site.

The natural sand-lime brick, being white or nearly so in colour, has the great advantage of being an admirable building material for the arid tropics where high reflectivity of sunlight is desirable. By the use of pigments the bricks can be coloured in pastel shades; a large proportion of the production has been of yellow, green and pink bricks.

RAW MATERIALS

Experiments with Calcareous Sands.—Preliminary investigations on the production of sand-lime bricks using lime produced by calcining the shelly beach sand were undertaken by the Building Research Station in the United Kingdom. The beach sand used contained about 50 per cent. calcium carbonate. In the final experiments the sand was calcined and then ground until the residue on a 100 B.S. sieve was 40 per cent. This was mixed with twice its own weight of uncalcined sand, and the mixture hydrated. When pressed at 2 tons per sq. in., with a moisture content of 6 per cent., bricks autoclaved at 180 lb. per sq. in. (for two hours at full pressure) gave an average compressive strength of 3,600 lb. per sq. in. This strength, is of engineering brick standard. This method of production is covered by British Patent Specification No. 745912, dated March 7, 1956.

Field Surveys in Kuwait.—Concurrently with work in the United Kingdom, detailed field surveys were undertaken in Kuwait to establish the whereabouts and quantities of suitable raw materials. It was soon found that most beaches on the Gulf coast of the State, for a distance of up to 100 yards inland, were composed of calcareous sand. It was also found, however, that this sand was almost the only sand in Kuwait of a grading suitable for concrete, plasters and mortars. Moreover, de-nuding the beaches would spoil the amenities of the houses which stretched in ribbon development behind most of the beaches within 20 miles of the main development area. The search was therefore concentrated on finding, firstly, deposits of sand which, although unsuitable for normal building work because of poor grading, did not contain objectionable impurities; and, secondly, on locating deposits exceptionally rich in calcium carbonate.

Location of a Sand Deposit.—Although most Kuwait sands are contaminated with gypsum, a deposit of over 2 million tons of reasonably pure sand was located close to the development area. This deposit alone should be sufficient sand for more than 20 years at full production, and at least two other deposits have been located in the vicinity. The sand was, however, very fine and the grading varied somewhat throughout the deposit. A typical sieve analysis is given in the accompanying table.

TABLE. *Grading of Sand*

B.S. sieve size	Percentage passing
⅜ in.	100
No. 7	95–99
,, 14	85–90
,, 25	80–85
,, 52	75–80
,, 100	50–60
,, 200	2–8

The sand was in a dune-like deposit, overlying gypsiferous material. Provided care was taken, contamination with gypsum could be avoided since the gypsum occurred at fairly well defined depths throughout the deposit.

Location of a Limestone Deposit.—An extensive deposit of calcareous material was located some 20 miles from the site of the proposed brick plant. This was a low-lying spit of land extending into Kuwait Bay and composed of dune-like accumulations of oolitic "sand" with low ridges of cemented deposits. This limestone is of very recent origin, and deposition is still occurring. The individual grains of the oolitic sand are composed of a chemically precipitated calcium carbonate and this sand contains as much as 98 per cent. of calcium carbonate. It is locally cemented by interstitial lime to form a soft limestone, also of high carbonate content. This soft limestone forms ridges up to 10 ft. high above the surrounding dunes. In addition, the area contains a stratum of hard shelly limestone some 3 ft. thick.

Tests made in the United Kingdom and in Denmark showed that lime with satisfactory slaking qualities could be burnt using this material. There was, however, a great variation in the calcium carbonate content and in the amount of impurities present. The carbonate content varied from 98 to less than 20 per cent. It was decided that material of less than 40 per cent. carbonate content was barely worth winning, but it was estimated that more than 1½ million tons of material with an average carbonate content of 66 per cent. could be obtained. This was estimated to be enough to supply the sand-lime brick plant for 20 years or more, even allowing for the production of twice the amount of lime actually needed for brick-making.

As a result of investigations in the United Kingdom, the impurities which could be tolerated in the sand and limestone were set at the following figures:

Magnesium carbonate (as MgO), not exceeding 3 per cent.
Sulphates (as SO_3), not exceeding 1 per cent.
Chlorides (as Cl), not exceeding 0·5 per cent.

Laboratory Experiments.—Further tests using sand and limestone from these deposits were carried out at the Building Research Station in the United Kingdom. It was found that, despite

the fineness of the sand and the unusual nature and great variability of the limestone, excellent sand-lime bricks could be made, provided adequate control was exercised during all stages of manufacture.

It was anticipated that using about 7 per cent. of lime (as CaO) in the sand-lime mixture, bricks with average crushing strengths of 1,900 lb. per sq. in. could be produced by autoclaving for 4 hours at 250 lb. per sq. in. Such bricks would be of adequate strength for normal building purposes. To obtain higher strength bricks for special purposes, say of 2,900 lb. per sq. in., it was anticipated that more than 7 per cent. CaO in the mix might have to be used.

In view of the great variability throughout the deposits of sand and limestone it was necessary to arrange for very detailed surveys to be made, and for trial pits and boreholes to be sunk and samples taken and analysed. Only in this way was it possible to ensure that enough raw materials were available. The information was also necessary to enable the deposits to be worked in such a manner as to provide for the plant a regular supply of fairly consistent raw materials.

BASIS OF DESIGN

In addition to the unusual nature of the raw materials a number of other factors affecting the design and layout of the plant had to be taken into consideration.

Output.—The Government of Kuwait required a plant to produce about 40 million bricks a year. It was realised that after the main development programme had been completed, say in 10 years time, the demand for bricks was likely to fall. Most of the machinery for lime and sand-lime brick production has an expected life considerably greater than 10 years and it was therefore decided to obtain the high output required in the early years of operation by double-shift working. The brick-making presses selected had a rated output of 2,500 bricks from each press per hour. Four presses operated for 16 hours a day for a five-day week would produce 800,000 bricks a week, or about 40 million a year. In order to permit maintenance and to allow production to be cut back in stages if required, the brick-making section of the plant was laid down in two production lines each including two brick presses. It would thus be possible to operate the brick-making section of the plant at outputs varying from 200,000 to 800,000 bricks each week, depending on the number of presses used and the number of shifts worked each day.

In order to provide lime which could be used as a substitute for cement in mortars and plasters, a lime kiln which would produce twice the amount of lime actually required for the brick-making process was to be installed. A gas-fired rotary kiln of this output, of more or less conventional design, would present no apparent technical difficulties in its manufacture—and would therefore benefit from the minimum of delay in its delivery.

The general layout provided for a lime hydrating and bagging plant, but this was not to be designed or erected until the Government of Kuwait was able to assess both the demand for lime for consumption in the country, and also the possibilities of an export trade. Although in Kuwait it would probably be acceptable to use " run of the kiln " lime containing varying proportions of silica, this would not be acceptable should it be decided to export. A decision on this point would radically effect the type of hydrating plant installed; it had not been possible to take this decision by the spring of 1957.

Owing to the varying delivery dates of the main sections of the plant it was decided to come into production on the brick-making section using imported hydrated lime pending the completion, some six to nine months later, of the lime-burning section. In addition to making bricks available earlier, this had the advantage of providing the management and operators with initial valuable experience in operating the plant.

Raw Materials.—The limestone deposit was in an isolated area, well away from the main plant. Maintenance would inevitably be difficult and for this reason plant at the quarry was limited to drills and excavators. The crusher was to be installed at the main plant. Tipper lorries were to be used for transport. Since much of the excavation would be below sea level it was desirable to build up stockpiles at the quarry to allow the material to drain and dry.

The sand deposit was shallow and of variable depth. For this reason tipper lorries, loaded direct by an excavator, were selected as being cheaper and more flexible in operation than movable conveyors.

Location.—The main development area was close to Kuwait town. The deposit of sand had been found alongside the main road to the oil fields, not far from the development area, and the plant was sited on the northern boundary of this deposit. Access was from an existing main road. The limestone provided the smaller tonnage of the raw material required and had to be hauled a distance of about 20 miles to the plant.

Services.—Because of the specialised nature of most of the machinery, considerable stocks of spares were ordered with the main items of the plant and store buildings were provided. As the plant was to be largely self-contained, workshops adequate for all routine maintenance were built together with offices and administrative buildings. A small laboratory for quality control of the lime and brick production sections was provided, the staff dealing also with flue gas and boiler-water analysis.

Climate.—During the summer months ambient air temperatures of over 120 deg. F. are not unusual. In the winter temperatures drop to around 40 deg. F. The high summer temperatures make working conditions very difficult, and for this reason the buildings enclosing those sections of the plant where men had to work were designed as light steel-framed structures with good over-head cover. Side sheeting was in general provided only where it was necessary to give protection from the sun to working positions. The building housing the boiler equipment was merely a " sunshade " of corrugated asbestos sheeting, with an air space, asbestolux sheeting, and crimped aluminium foil. Even in the height of summer this has proved to be one of the coolest of the non-airconditioned buildings in Kuwait. As far as possible the machinery was left without buildings around it. The absence of buildings and, even where they existed, the omission of side-sheeting, meant that the sand and lime had to be adequately protected against dispersion by wind and clogging or premature hydration by rain; elevators and drag chain conveyors were therefore fully encased, and belt conveyors were protected with dog-housing.

The rainfall in Kuwait is very small, amounting normally to about 3 to 5 in. a year, and occurring in a few heavy storms during the winter months. Protection against rain was secured by covering in the conveyors, especially those carrying quicklime.

The plant has been built in the desert. There is always some dust in the air and, during the summer season, the *shamal* frequently blows. This is a heavily dust-laden wind. Wherever possible machinery was protected against the entry of dust, and all electric motors were totally enclosed. Where protection was impracticable, reliance was placed on adequate maintenance but it was anticipated that, as with most other activities in Kuwait, the plant would (except for the kiln) close down during the height of a *shamal*. At this time brick presses and the like would be sheeted over, and careful cleaning and greasing would be necessary before starting up again.

Fuel and Power.—Large quantities of natural gas are available from the oil fields. This was being piped into Kuwait Town and most of the industrial installations, such as the water-distillation plant and power station, were designed to operate on natural gas. The boiler house and lime kiln were to be similarly operated, the gas being supplied through a branch main to the plant at an incoming pressure of 165 lb. per sq. in.

The sand-lime brick and lime plant in Kuwait. It has a gross capacity of 40,000,000 bricks a year. Brick-making was begun before the kiln was completed and the first bricks were made using imported lime.

Continuing Bricks from Sand

The gas used had a typical analysis approximately as follows:—

Constituent:	Methane	Ethane	Propane	Nitrogen	Carbon dioxide
Percentage	75·0	12·0	4·5	3·0	2·5

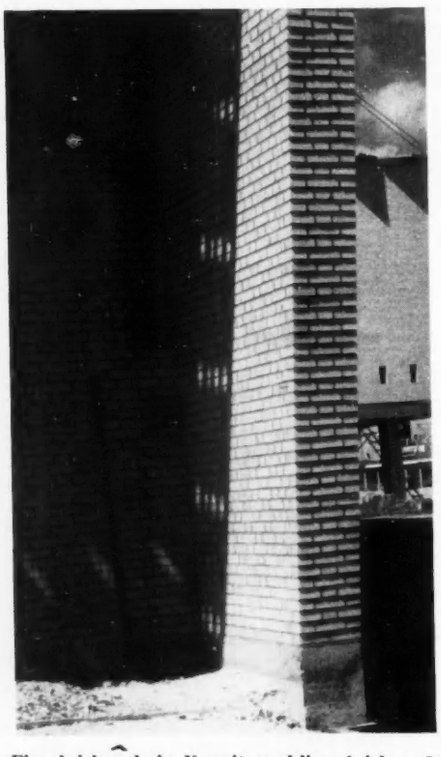
The calorific value of the gas was 1,195 B.Th.U. per cub. ft. While natural gas may have the advantage of cleanliness in operation, it was found by practical experience to have many drawbacks. These are discussed in a second article under the commissioning of the plant.

As natural gas was so freely available it was possible to design both the lime kiln and the boiler house without giving as much weight to considerations of fuel economy as would have been the case where fuel was less abundant. This provided a saving both in capital cost and in complexity of design and operation, especially as regards the lime kiln.

A new power station was under construction at the time that the brick plant was being planned so the whole of the machinery was to be driven by electric motors. The total rated capacity of all the motors used is about 800 h.p. A small donkey engine, driven by a Diesel engine, is provided to turn the kiln in the event of electricity failure.

Water.—All naturally occurring waters in Kuwait are brackish and unsuitable for boiler feed water. As a very large sea-water distillation plant was being erected to provide drinking water for the population of Kuwait, arrangements were made to use this water for the brick plant in order to avoid setting up a separate water-purification unit. The greatest economy had to be exercised in the use of the scarce and expensive distilled water, and in this connection the design of the brick plant included means for recovery of the condensate water from the autoclaves. This water, picking up only small quantities of dissolved solids (principally lime), would be suitable for slaking lime for brick-making and also for the lime-hydration plant. A small unit was provided to treat condensate water, should it be necessary to use it as make-up water in the boiler house.

Lime Kiln.—As indicated above it was a requirement of the design that the kiln had to be capable of producing twice the amount of lime actually required for brick-making. The quality of the limestone varied considerably and it was considered that, over a period of 20 years, the average calcium carbonate content would be about 66 per cent. Allowing for continuous operation of the kiln 24 hours a day, with provision for periods of inactivity to allow for maintenance and re-lining, it was calculated that an input of about 300 tons a day was necessary. With a calcium carbonate content of 66 per cent. it was calculated that such an amount would produce about 100 tons of lime (as CaO) a day. The balance of 200 tons was accounted for by 100 tons of silica and other solid impurities, and about 100 tons of CO_2 which would be discharged to the atmosphere.



Fine brickwork in Kuwait sand-lime bricks. It compares favourably with any in the world.

For the construction of the Kuwait sand-lime brick plant most of the labour was recruited locally. Erection was undertaken by the Public Works Department and local labour is now operating the plant.

Much of the principal limestone deposit had been found to consist of unconsolidated oolites and the kiln had to be capable of handling this fine material as well as the shelly sand commonly found along the beaches.

The kiln was therefore designed for an input of 300 tons a day. With experienced burners this could be reduced to about 100 tons a day. This low input will be necessary at times pending the installation of the separate hydrating plant to treat the quicklime not required for brick-making.

Brick Presses and Lime Hydrating.—Conventional electrically-driven toggle-operated presses were selected for the brick-making operation, the principal considerations being price and delivery. The method of hydrating the quicklime, mixed with sand, under pressure in a drum hydrator was selected. While tests in the United Kingdom had shown that lime burnt from Kuwait materials slaked satisfactorily, it was found that there was considerable variation between samples. All the limestone deposits contained impurities, notably silica. The system of hydration adopted was thought likely to provide the best safeguard against the presence of unhydrated particles in the bricks on entering the autoclaves: this, as is well known, being one of the chief difficulties in sand-lime brick manufacture.

Boilers.—Although more efficient boilers could have been installed, it was considered that the ease of operation and maintenance of the Lancashire-type boiler outweighed any savings which might be made in fuel consumption. Two boilers were installed, one as a stand-by, each with associated controls and instrumentation for operation on natural gas.

Brick Disposal.—In view of the short hauls involved, and of an already established tradition in Kuwait, it was arranged that contractors requiring bricks would collect them in their own transport from the brick plant. Thus no provision was made for brick transporters.

A second article will deal in greater detail with the plant installed and will give some facts about the bricks produced.

ADAPTING INVESTMENT TO WORLD TRADE

The Government's anti-inflation measures aim at restricting investment. On the other hand, there have been various warnings that Britain just isn't investing enough. An article by Dr. T. Barna in *The Banker* suggests that the real answer is that we have been putting our money on the wrong horses. In the nine years to 1956 a total of £6,100 million was invested in British manufacturing compared with £5,300 million in Western Germany manufacturing, both at end 1957 prices. Since 1954, however, German investment has been much the higher. In spite of its low level in the earlier years, German investment even then equalled or led Britain in building materials, iron and steel, non-ferrous metals, mechanical and electrical engineering, and paper. In the three years 1954 to 1956 German investments in iron and steel were more than twice Britain's. Not only has the capacity of the German steel industry exceeded that of Britain, but the Germans have a much greater capacity for producing equipment for the industry. Only in industries producing mainly consumer goods—textiles, clothing, food, drink, tobacco, paper and printing and rubber—does Britain compare favourably.

Although investment even in declining industries may release labour for use elsewhere, Dr. Barna thinks that the investment pattern of Germany is better adapted than ours to the changing trends of world trade. This is because the pattern of British exports of manufactures is still not so well adapted to world demands. The four most favourably placed commodities—motor vehicles and aircraft, machinery, iron and steel, chemicals—accounted for 56 per cent. of Britain's total exports in 1955, but for 63 per cent. of Germany's and 72 per cent. of those of the United States. Structural changes in British industry have gone a long way, but more investment in industries of importance in world trade and less on consumer goods seems to be required.

The Human Element

Attracting Experience to Research

The latest revise (as at January, 1958) of *Notes on D.S.I.R. Grants for Graduate Students and Research Workers* (H.M.S.O., price 1*s.* 6*d.*) has now been issued. It introduces a number of modifications in the method of award. In 1957 there were altogether 1,453 post-graduate studentships given and this year the D.S.I.R. hopes to offer at least as many.

The value of the awards is not to be significantly altered but the age limit of those qualifying for increased payments because of at least two years graduate experience in industry has been reduced by two years. The object is to attract back men with some experience without their having to accept a drop in salary. As in 1957, initial applications for research studentships will be made for a quota of awards for a research school and individual candidates can be named later. Those wishing to study abroad however must be sponsored individually not later than April 1. In future the Department will consider the payment of dependents' allowances in certain cases.

Redundancy Precedent?

The twelve-day strike by some 2,000 employees of the cycle division of Tube Investments Limited ended last week when the company agreed to pay compensation to 80 workers who had become redundant. The agreement, signed by the Transport and General Workers' Union, the Amalgamated Engineering Union and the National Society of Metal Mechanics, is the first to be reached with the T.I. group which covers dismissals necessitated by trade recessions. As such it is likely to set a pattern for the many similar situations likely to occur in the engineering industry during the next few months.

The unions had backed the strike on the ground that the dismissals were made without prior consultation with union officials. The demand for the men's reinstatement was not granted but they are to receive a week's pay as compensation. The new agreement provides for two weeks' warning before redundant workers are served with dismissal notices. This will allow time for negotiations, for example on questions of seniority and on the selection of the men concerned. Compensation will be paid on a scale ranging from one week's wages for employees of three years' service up to four weeks' wages for those who have been with the company for 25 years or more.

The main difficulty facing companies with dwindling order books is one of timing. If the general pattern of this agreement is followed by other companies it means that a decision needs to be made almost a month before it can be implemented. Companies with an order book problem will be tempted to play safe and reduce their labour force well in advance of the critical point. But prior notice, and therefore a great deal of wrangling, with compensation, have clearly come to stay.

Miners in the Wage Salient

With the conciliatory gesture at the end of last week from the London bus workers not to take strike action, the interest in the wage struggle shifts for the time being to the railways and the mines.

Last week the National Coal Board turned down the dual claim for a shorter basic week for surface workers and a sickness pay scheme for manual workers. On the day of the rejection the miners' leaders agreed to make a large official pay demand—it is thought for a rise of 10*s.* a week, which would cost the industry something of the order of £18 million a year. The industry is in poor shape to meet such a demand without Government financial assistance in the form of toleration of deficit operations or higher prices, but both of these are against the present economic policy.

There is the added complication in the coal industry so far as wages are concerned that there has been nothing approaching a fight since the war. The National Union of Mineworkers have openly boasted at union congresses about the clever way it has dealt with the Coal Board of recent years. That being so, prestige may become involved if the Board says no. If the N.U.M. does not show fight there will be plenty of professional unionists in other big unions who will make pointed remarks about cocks that crow.

Fraternity—With Reservations

The acute suspicion, amounting to distaste, with which the French Government and organised industry is viewing the present proposals for the Free Trade Area, is being re-echoed by organised French labour. The Communist-led unions are favourably disposed to it since they hope that it will help to wreck the European Common Market scheme. The rest of the big union groups prefer the E.C.M. to the F.T.A.

Intellectually the unions are split as might be expected. Those with Catholic affiliations favour the preservation of the E.C.M. idea. The rest prefer the wider association of the F.T.A. The same kind of split can be found, incidentally, in Germany among both employers and workers. So far as France is concerned, however, when it comes to the point, most influential unionists think primarily as Frenchmen. That is to say, they see the safeguards for France written into the now ratified Treaty of Rome, and they observe the bleak, exposed position for France's high-cost industries offered (as they understand the British proposals) by the Free Trade Area. They also see the F.T.A. being used, if it is not modified drastically to come into line with the E.C.M., as a means of damaging France's safeguards under the Treaty of Rome. Why, they ask, should the six members of the European Common Market expect better terms of economic co-existence from one another than they get from the associated members of the F.T.A.? Equality like misery acquaints a man with strange bedfellows.

New Style Profit Sharing

Workers in the United States motor industry have broken new ground in their recent demand for a share of manufacturers' profits. The United Automobile workers announced last week that they will press for a share-out of all profits above 10 per cent. on investment, when contract negotiations open in the spring. Their proposals are that half should go to the company for disbursement to shareholders and in executive bonuses, 25 per cent. to all wage and salaried employees other than executives and 25 per cent. in rebates to consumers who had bought the company's products during the year.

The inclusion of customers in the share-out suggests that the U.A.W. may have substituted profit-sharing to the four-day week for five days' pay. Their leaders have been worried for some time about their industry's inability to maintain production at full capacity and they are clearly anxious not to make the task more difficult. Nevertheless, opposition to the profit-sharing demand is likely to be very strong. It represents an intrusion by trade unions in a field hitherto jealously guarded by employers and they will oppose any attempt to set a precedent.

The U.A.W. also announced their intention to seek an end to the differences in wage scales between the motor companies—thus making the task of the smaller units more difficult or forcing amalgamations—and an improved cost-of-living formula. The issue of redundancy is becoming more acute and the union will press for supplemental payments to workers laid off, with the maximum benefit period extended from six months to a year. Should these demands be successful the industry may find it increasingly difficult to get the capital it requires, with consequent hardship for all concerned.

Spreading Teachers over the Bulge

The battle of the educational bulge is now on in earnest. The high birth rate after the war is now producing an extra crop of children at the early stages or on the verge of secondary education. While this bulge lasts, say for five years, the educational system must feel the strain right up through the various stages to advance education. Worst of all is the shortage of teachers.

The quota system started last year has somewhat improved the position according to the Ministry of Education. One of the difficulties has been that the number of teachers coming forward has not come up to expectation. This year looks like being a critical one. It starts off with the handicap of a shortfall in supply from the start. The object of the quota scheme is for each area to have a figure beyond which it is not encouraged to recruit teachers. Teachers are not discharged if they are above the quota number but some control is expected to be exercised through loss by natural wastage.

Seven and Fourpence for the Blind

A skilled machinist was expelled from his union last week for refusing to conform to a factory agreement according to which all earnings in excess of £18 a week could be paid into a sick fund. The local branch of the Amalgamated Engineering Union to which he belonged decided that his conduct had been " detrimental to the union " and demanded that his employers should dismiss him. The works manager said that if the union wished to press the matter he would dismiss the man rather than risk a strike.

The man's point of view is simply that any limit imposed on earnings is a restrictive practice and he is no longer willing to put up with it. His workmates say that he was a party to the agreement and that union men (it is an all-union shop) cannot keep among them workers who break agreements. The sum in question—7*s.* 4*d.*—was paid by the offender into a collecting box for the blind.

Such issues are never as simple as they look. There is usually a background of relationship, mounting friction or frustration which rarely comes to the surface. In this case too little is known to pass judgment except that an individual's rights, and particularly those to work as hard as he pleases, are something society should guard most jealously. The worker concerned may yet find that the A.E.U. executive, who have to ratify the decision of the board in such matters, may not concur. Already the branch officials have been told that the expulsion was " unconstitutional " and the matter has been referred to the local district committee. The latter could recommend to the national executive that the man be expelled and their recommendation would probably be acted upon. But even then the man has the right of appeal. All this means that nearly a year must elapse between the " offence " and explusion. The machinery to safeguard the individual's right is thus available. Bad tempers should not prevent its use.

Atomic Review

First Steps in Fusion

At six p.m. to-day details of British research on the controlling of thermonuclear reactions will be released to the public. They will provide the first official evidence that energy evolved in the fusion of light nuclei can be made available for the practical generation of electric power. Already reference has been made in ENGINEERING to ZETA (zero-energy thermonuclear apparatus), the equipment at Harwell by means of which this evidence has been obtained (Atomic Review last August 2); and a complete background to the subject was given by Dr. A. A. Ware, of the A.E.I. Research Laboratory, Aldermaston, in an article "Controlled Thermonuclear Reactions," published in ENGINEERING last November 15, page 610, and now available as a reprint. It is known that successful results were obtained with ZETA in August last year, but at the same time work was in progress at the Atomic Weapons Research Establishment, Aldermaston; and at a conference of the Physical Society results were presented showing that fusion reactions had been achieved. It should be emphasised that in spite of these successes, commercial fusion reactors may still be as much as 10 or 15 years away. Details of the ZETA experiments will appear in Atomic Review next week.

Criteria for Fusion

If two nuclei are to approach each other sufficiently closely for fusion to occur, means must be discovered of overcoming the mutual repulsion due to their electrostatic charges (the Coulomb barrier). Clearly if the nuclei are moving towards each other at high speed their inertia forces may overcome this resistance with a battering-ram effect. It will be apparent that to add a neutron to the proton nucleus of ordinary hydrogen, so forming heavy hydrogen or deuterium, will be to increase the inertia force, since the mass is doubled, but not to increase the Coulomb barrier, since the charge remains the same. Hence, deuterium or tritium (a proton and two neutrons) will fuse more readily than ordinary hydrogen.

One method of raising the velocity of nuclei is to accelerate them to high energies in particle accelerators, but this procedure is unlikely to yield an economic approach to fusion since losses are very high, and more energy will be required to accelerate the particles than will be produced in the reactions that occur. However, by raising the temperature of a mass of hydrogen gas to a sufficient value the random motion of the nuclei may become sufficiently agitated, in accordance with kinetic theory, to give the relative velocities required. The methods employed for this purpose, which are discussed below, do however produce other effects giving rise to fusion (accelerating fields, for example), and to distinguish between these less-desirable mechanisms and genuine thermonuclear fusion is very difficult.

Neutron Emission

In order to prove that thermonuclear reactions have occurred it is necessary to demonstrate that the neutrons evolved in the experiments are thermonuclear in origin. The method by which this is done is largely negative, in that thermonuclear neutrons are regarded as those that cannot be accounted for by any other mechanism. Since it is always possible that some mechanism may have been overlooked, conclusive proof is difficult. However, the experiments at Harwell and Aldermaston show to a very high degree of probability that neutrons observed were produced in the course of fusion reactions. The problem of identification is treated in greater detail in the paragraphs below.

Work at Aldermaston

Last October 25, a paper by Dr. H. A. B. Bodin and Dr. J. A. Reynolds of A.W.R.E., was published in ENGINEERING (page 538), in which the following statements, were made. "In this paper a brief account is given of some of the work being done at A.W.R.E., Aldermaston, into the properties of high-current transient discharges in deuterium gas. Neutron yields of the order of 10^5 were detected, showing that the following nuclear reaction occurred:—

$$D + D = He^3 + n$$

[This reaction is accompanied by the emission of 3·25 MeV units of energy.]

"This indicates that high energy deuterium ions were present in the discharge although the mechanism by which they were produced is not yet clear. Two explanations will be considered. The first is that a large number of ions were heated in the discharge to thermonuclear temperatures of a few hundred electron volts, and the other is concerned with a non-random motion produced by accelerating electric fields arising from instabilities in the discharge."

The paper on work at Aldermaston was entitled "Neutron Emission in High Current Gas Discharges" and was presented initially at a conference of the Physical Society. The paper was later published in full in ENGINEERING. Figs. 1, 2 and 3 show results obtained at Aldermaston. The paper read by Academician Kurchatov at Harwell, giving details of Soviet work on pinched gas discharges, was published in ENGINEERING, vol. 181, page 322, 1956.

Recognising Thermonuclear Fusion

"The unequivocal way of differentiating between the two methods of neutron production," state Bodin and Reynolds in their paper, "would be to measure the angular distribution of neutron energy about the tube by, say, proton recoil tracks in a photographic emulsion. The thermonuclear neutron energy distribution should be isotropic whereas the instability neutron energy should show an anisotropy in the direction of the accelerating field acting on the deuterium ions . . .

"We have produced a high current pinched discharge in deuterium which, by current and pinch-time measurements, should have a temperature high enough to produce an appreciable thermonuclear reaction. We have detected neutrons emitted from the discharge, which in some respects have thermonuclear properties, but the yield is too low to decide one way or the other."

The neutron yield from a discharge can indicate the type of neutrons present, provided sufficient information is known about the conditions existing within the discharge. It is possible to check whether a given yield is consistent with the current flowing. Even in the absence of details concerning such factors as the compression of the gas, quantity of gas ionised, and the ion/electron temperature equilibrium, a rough estimate can be made that will indicate the order of yield to be expected if the neutrons are thermonuclear in origin.

In addition, the variation of neutron yield with amount of impurity within the gas and with the strength of an applied axial magnetic field can give a clue as to the origin of the neutrons observed in a discharge. The impurities and magnetic field each have the effect of cooling the gas. At high neutron yields quite small traces of impurity quench the yield of instability neutrons; and small magnetic fields have the same effect.

ZETA

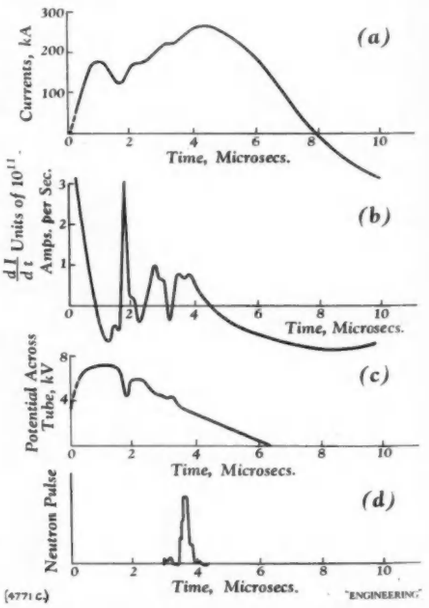
ZETA, which is reported to have cost £250,000, was designed and built by the United Kingdom Atomic Energy Authority in collaboration with the Metropolitan-Vickers Electrical Company, Limited. It comprises a torus generally containing deuterium (heavy hydrogen) through which a pulsed electrical discharge is passed; the gas ionises and in accordance with the well-known electromagnetic pinch effect contracts away from the walls of the torus, so insulating the electrically heated ion plasma or gas filament from the vessel. In ZETA temperatures of the order of 5 million deg. C. have been achieved. (A recent Soviet claim refers to temperatures of only 1 million deg. C., whereas even in earlier small-scale equipment at Harwell temperatures of 2 million deg. C. are said to have been reached.) It should be emphasised that these temperatures are achieved for only a matter of microseconds. The main problem is stability, since the discharge tends to wriggle, thereby touching the walls of the vessel and causing them to vaporise. Several methods of reducing instability have been suggested including specially shaped vessels and the introduction of secondary magnetic fields.

Energy Balance

Though 5 million deg. C. is sufficient to bring about some reactions during the discharge, the number that occur is insufficient to give a positive energy balance, since considerable

The large peak in this typical scintillation trace (8 microsecs long) is caused by neutrons arriving at the counter. The smaller pulses—each equivalent to about 10^3 neutrons emitted from the discharge—are due to cadmium capture.

In 1 per cent. of the discharges large bursts of about 10^6 neutrons were observed.



The current and voltage variation during a discharge may be compared with neutron yield.

Fig. 1 Controlled thermonuclear fusion has been the subject of work at Harwell, at A.W.R.E., Aldermaston, and elsewhere. Successful experiments were performed as early as August last year, and these scintillation traces published in ENGINEERING last October provided evidence of the progress made by Aldermaston workers.

energy is consumed in the apparatus in creating the high temperatures and in heat losses to surroundings. If reactions are to proceed at a desirable rate temperatures of 50 or 100 million deg. C. would be necessary.

Power from Seawater

The result of solving the immense technical problem of building a commercial fusion reactor would be to have almost limitless fuel resources. Dr. P. C. Thonemann, one of the leaders of the British team engaged on this work, has suggested that, given the deuterium content of ordinary water, one cup-full of seawater is roughly equivalent to 5 cups-full of petrol, with certain reservations. This figure allows for the energy consumed in separating the deuterium from normal hydrogen, but heat losses and other causes might alter it substantially; Dr. Thonemann says that it might be inaccurate by a factor of 100 either way. The separation of heavy water from light water can be carried out at a cost of something like £25,000 a ton, though two-purpose separation plants, the use of geothermal steam and economies of scale might alter the cost considerably. It has been pointed out in the *Manchester Guardian* that this estimate for the separation of the heavy isotope corresponds to about 1 per cent. of the cost of carrying the energy equivalent of coal from collieries to British consumers.

Other Fuels

It should be emphasised that other fuels might be used, but a compromise between abundance and operating temperature gives deuterium as the most likely choice. Tritium, or superheavy hydrogen (H^3), obtained by neutron irradiation of lithium, would be ideal, but is necessarily scarce; normal hydrogen would require vastly higher temperatures. In addition it is worth pointing out that the neutrons produced in the reaction might be used for irradiating lithium or for the production from uranium 238 and thorium of the fissile fuels plutonium and uranium 233.

Cold Fusion at Liverpool

Dr. Alick Ashmore, Dr. Ralph Nordhagen, Professor Karl Strauch, have been working together at the University of Liverpool and observing the way in which μ mesons can catalyse fusion of hydrogen isotopes under laboratory conditions without the use of high temperatures. The work was discussed recently at a Harvard University Physics Department colloquium. Reference to the process was made in Atomic Review on January 11, 1957. References to other experimental methods of achieving fusion reactions were discussed in Atomic Review last January 10.

The investigation was begun as a result of the discovery (by a group of scientists under the leadership of Professor Luis Alvarez at the University of California) of peculiar tracks in a hydrogen bubble-chamber attached to the Bevatron. A bubble chamber is a vessel filled with liquid which shows the tracks of charged particles as bubbles. This bubble chamber was inside a strong magnetic field which caused charged particles to curve. The particular track observed could not be explained by any reaction or particle then known. Analysis of the curvature of the track and the gaps it possessed showed that the initial part of the track was due to a μ meson (or muon). The muon is a fairly recent addition to the subnuclear family, with a mass about two hundred times as great as the electron's. The muon is unstable, breaking down into an electron and two small chargeless particles called neutrinos in two microseconds. This particle had attached itself to the nucleus of a deuterium atom, a form of heavy hydrogen, which occurs in nature as one heavy atom in every 5,000. The deuterium atom, with the muon still attached, then joined with an ordinary hydrogen nucleus to form a mesic hydrogen-deuterium molecule in which the muon replaces an ordinary electron. This mesic molecule is inherently unstable, in that energy is released when the hydrogen and deuterium nuclei fuse together, forming a helium nucleus.

However, this fusion with its subsequent energy release is possible only when the hydrogen and deuterium come close together. This event is highly unlikely in an ordinary molecule in which the two nuclei are held at a distance of about a hundred-millionth of a centimetre by an electron. But when the electron is replaced by a muon, this distance is reduced by a factor of two hundred, the ratio between the muon and the electron mass. The greater closeness of the nuclei in the mesic hydrogen-deuterium molecule increases the probability of fusion enough so that it can occur within the two millionths of a second lifetime of the muon. In the events observed by the California group, the muon was thrown out of the helium nucleus after the fusion so that it could take part in other reactions. During this whole process the muon was unaffected, acting much like a catalyst in a chemical reaction.

Unfortunately, as the experiments at Liverpool showed, there are difficulties which will keep this reaction from commercial use. To be a practical source of energy, any reaction must release more energy than that required to start it. The two factors which prevent the muon-catalysed fusion reaction from reaching practicality are, first, the short lifetime of the muon, which limits the number of reactions it can start, and second, the unfortunate fact that the helium atom very seldom ejects the muon when the reaction is finished, but usually sends out a gamma ray instead. This cuts down the number of muons available to start new reactions, and the reaction in the hydrogen damps down and finally dies away.

(Nevertheless a Soviet physicist Alikhanian is said to have postulated the existence of a suitable long-lived negative meson, and Professor Danysz at the Dubna research institute, U.S.S.R., is understood to be preparing an experiment for one of the institute's accelerators to test Alikhanian's calculation.)

Announcement on Controlling Fusion

Announcements on the current state of research in the field of controlled thermonuclear reactions are to be published simultaneously by the United Kingdom Atomic Energy Authority and the United States Atomic Energy Commission at 18.00 hours G.M.T. on January 24. Since 1956 there has been a continuing and complete exchange of information between the Authority and the Commission in this field. The collaboration naturally includes consultation on the timing of any announcement of results obtained. Anglo-United States co-operation has covered work in the classified (that is, secret and confidential) as well as in the generally unclassified categories.

It was recently decided by the two countries to declassify work on controlled thermonuclear reactions except for certain areas of advanced work. It is this freeing of certain information from security restrictions which has made possible the publication of details about the current state of research.

When the revised classification regulations made a further release of information possible the timing of the announcement was considered by the Authority and the Commission and it was decided to arrange for simultaneous publication of information about the results obtained in research establishments in both countries as soon as all the papers could be made ready. It was this sequence of events which led to the choice of January 24 as the date of publication.

Fusion References

Previous notes and articles on the fusion reaction have appeared in ENGINEERING as follows: vol. 180, page 234, 1955; vol. 181, page 318, 322, 355 and 409, 1956; vol. 182, pages 124 and 187, 1956; vol. 183, pages 33, 58, 121, 217 and 540, 1957; vol. 184, pages 29, 156, 347, 474, 538, 610, 764, 827 and 828, 1947; and vol. 185, page 43, 1958.

High-Activity Materials Handling

A building recently completed at Harwell has been designed for the safe handling of highly radioactive materials, and in particular for the opening up of test loops which have been irradiated in the research reactors (or other Authority's plants). The samples can then be examined by scientific staff. The construction is such that activity levels up to 100,000 curies can be handled normally and even higher levels in special cases. As will be seen from Fig. 1, the building consists of a series of cells in which the material can be handled under remote control. A second series is planned for materials whose radioactivity does not exceed 10,000 curies. Around these cells are the ancillary service sections. The office accommodation has been kept to a minimum.

Opening Test Loops

The normal procedure would probably be as follows. The test loop would be delivered in its transport flask at the receiving bay and unloaded by the 25 ton overhead crane. It would then be placed on a hand propelled bogie running on steel rails for transfer to the first cell. The transfer bay into which it would first enter can be sealed and the door in the cell wall swung open. Test loops up to 12 in. square and 12 ft. long are the normal size limits, but it is possible to introduce more bulky equipment. As a general rule the first and second cells will be operated as one and will be devoted to the opening of the test loop. A radiographic unit will be used to prevent the test sample being cut during the opening. In the third cell is a milling machine, the fourth is equipped for metrological inspection and the fifth for physical tests. A second transfer bay completes the row of cells.

Master Slave Manipulators

For handling the material each cell is provided with a pair of Savage and Parsons master-slave manipulators, and running on rails over all five cells and the second transfer bay are a General Mills power manipulator and a 1½ ton crane. The control panels for these plug into the main control panels of each cell; both are fed by power cables wound on drums in the roof. In addition there is a battery-driven 5 ton bogie which runs on rails through all the cells for carrying heavy items. This is also necessarily controlled from the main gangway and a novel system has been employed to avoid the nuisance of trailing cables. An electric loop has been made round the guiding rail so that the latter can be magnetised in either direction. Corresponding magnetic relays on the bogie then operate according to the direction of magnetisation and the bogie moves either to the right or left, as desired. Again the control panel plugs into the main panels between each cell.

Cells

The walls enclosing the cells are made of normal concrete, 5 ft. 6 in. thick. Normal concrete was chosen on account of the saving in cost over dense material. The partitions between the cells are 2 ft. thick and those to the transfer bays 2 ft. 3 in. thick. All the partitions are of steel tanks containing steel shot concrete of density 350 lb. per cub. ft. To enable the handling gear to move from cell to cell, half of each partition wall can be withdrawn through the rear wall by electric power and the top section can be lifted by hydraulic power to allow the crane and manipulator to pass. It is also possible to jack the front half of each wall through the rear wall (following the path of the rear half) so that two cells can be thrown into one. In fact any arrangement between five cells of 8 ft. and one cell of 40 ft. is possible. All the cells are 10 ft. 6 in. deep and 16 ft. 6 in. high.

To enable material to be withdrawn directly from each cell and also to allow frogmen to enter for cleaning, there is a plug door in each rear wall. These, weighing about 11 tons each, can be withdrawn by a hand ratchet geared to

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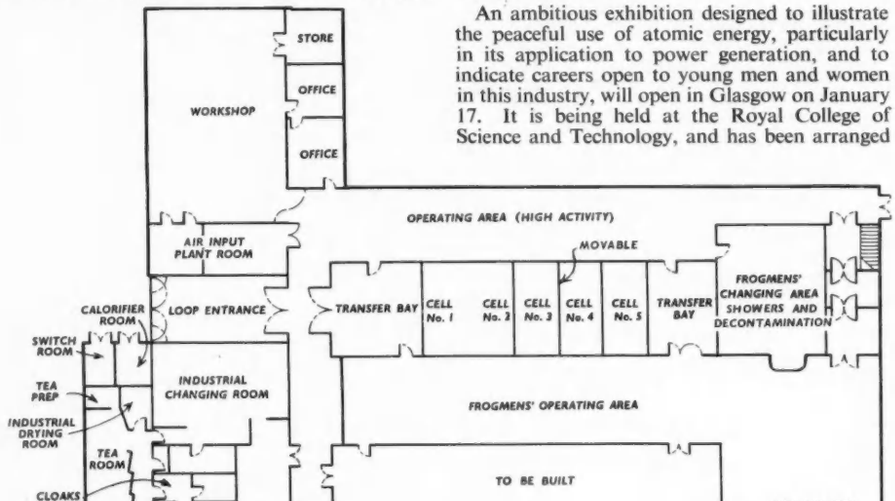
the running wheels. Simplicity has been the aim of all operating gear particularly that in the frogmen area which is subject to considerable contamination.

Operations within the cells are viewed through windows in the front wall. These are 5 ft. by 3 ft. and are the same thickness as the walls, namely 5 ft. 6 in. They are built up of eight thicknesses of glass containing zinc bromide, with a facing layer of distilled water to prevent reflections. The high refractive index of the zinc bromide enables more of the interior of the cell to be seen than would be possible had the windows been of glass. However, the light absorption is about 50 per cent. so twice the normal number of sodium lamps have to be used. An unusual feature is that the windows are mounted in resin bonded glass fibre, instead of steel frames.

Ventilation

The ventilation plant has also been arranged



to produce the minimum risk of spreading contamination. A single input fan blows air through a bank of Vokes type 44 filters into the building and two fans draw out the used air through a bank of Vokes 55 filters. The input fan is equipped with filters to reduce the rate of clogging of the output filters which, naturally, are contaminated, and so offer a disposal problem. The flow of air is arranged always towards the areas of higher radioactivity; in the cells a negative pressure of about 0·7 in. of water exists and elsewhere about 0·3 in. Air enters from the ceiling and is extracted through the floor in each cell.

Cleaning by Frogmen

Running behind the cells is an area in which frogmen can operate. In a central control room is an intercommunication set through which the controller can talk to the men, and the men to each other. The controls for paying out the hoses are also there. From their centre the men can enter the cells for cleansing and can reach the extraction air filters by mounting the steps leading to the space above the cells. Also in this space run the services to the cells. The normal cleansing procedure in the cells is to use the manipulators to reduce the gamma level to a reasonable figure before the men enter; working with the manipulators is however very slow. A 10 ton crane runs over the frogmen area.

General Notes

Nuclear Conference for Fringe Industries

The growth of nuclear engineering affects not only those firms concerned directly, but also firms still only on the fringe of these developments. Such firms may benefit both as suppliers to the nuclear industry and as consumers of its products and by-products. To cater for the needs of the fringe industries the Federation of British Industries is convening a conference to be held in Eastbourne on April 10 and 11 followed by a visit to the Atomic Energy Research Establishment at Harwell on April 12. The F.B.I. Conference on Nuclear Energy will have as its chairman Sir Claude Gibb, managing director of C. A. Parsons and Company, Limited. Speakers will include Sir Edwin Plowden, Chairman of the U.K.A.E.A., Dr. D. J. Littler, Principal of the Harwell Reactor School, and Dr. H. Seligman, Head of the Isotope Division, U.K.A.E.A.

Glasgow Nuclear Exhibition

An ambitious exhibition designed to illustrate the peaceful use of atomic energy, particularly in its application to power generation, and to indicate careers open to young men and women in this industry, will open in Glasgow on January 17. It is being held at the Royal College of Science and Technology, and has been arranged by the Industrial Group of the United Kingdom Atomic Energy Authority. While the exhibition is open, from January 17 to 25, the Royal College are opening some laboratories to visitors.

Carbon Dioxide Filters for Bradwell

A contract for carbon dioxide by-pass and drier filters for the nuclear power station at Bradwell has been placed with Mancuna Engineering Limited, Denton, by C. A. Parsons and Company, Limited, a member company of the Nuclear Power Plant Company, Limited.

G.E.C. Tests Burst Slug Detection Gear

In the General Electric Company's laboratories at Erith, now enlarged by taking over further premises, a large number of experiments has been conducted on all aspects of power-station design, not only for those parts of the Hunterston station that were not already finalised, but also for future developments. Work has included the design and extensive tests of B.S.D. (burst slug detection) gear for installation in a reactor to detect possible bursts in fuel element cans. Values of radioactivity are recorded in turn at every fuel channel, and automatic warning is given of any serious increase. Both Salford Electrical Instruments Limited and the G.E.C. Telephone Works, Coventry, have collaborated in this project.

Uranium Requirements

Dealing with the world's future requirements for uranium in *Optima*, Sir Edwin Plowden considered that the demand for military purposes in an "undisarmed" world would continue at about the present level, while any temporary falling off due to general nuclear disarmament would soon be made good by increased requirements for civil purposes More than 800,000 tons of uranium oxide were workable by existing techniques and low-grade concentrations, which could not at present be economically exploited, amounted to tens of millions of tons. During the 1960's and 1970's the civil demand would be primarily for power generation and by the end of this period would probably reach between 5,000 and 10,000 tons per annum in this country. It was estimated that by the same date the annual consumption in the United States would be from 20,000 to 30,000 tons and the demand in the free world 50,000 tons. Although by 1960 the probable production of uranium oxide would not exceed 40,000 tons per annum there should be an ever-growing market for economical sources of supply.

Fig. 2 (above) A building recently completed at Harwell has been designed for the safe handling of highly radioactive materials and in particular for opening test loops following irradiation in a reactor.

Fig. 3 (right) View of cell operating face in the high-activity handling building, Harwell.

Companies in the News

Sticky Business

Oil output increased last year more slowly than in any of the past five years. If the Soviet bloc countries and China are excluded, output rose by only 4 per cent. to 768 million tons, which compares with a 7½ per cent. increase in 1956. Stocks are high everywhere and the increase in production this year is likely to be once again below the average of recent years. The main hope of a large increase in this country lies in an expansion of domestic usage and for heating generally. Some half a million convector fires are being sold a year and the sales of oil-fired boilers are also on the rise.

Despite the slackening in the rate of increase most companies are going ahead with expansion plans. Esso Petroleum announced recently that they had received approval by the Ministry of Housing and Local Government for the erection of a refinery at Milford Haven on a 300 acre site. There appear to be few doubts among British companies that the rate of increase in consumption will quickly rise again, despite the surplus of small coal which has developed over the past few weeks. This doubtless influenced the Minister of Power in making a cut of 2 million tons a year in the Central Electricity Generating Board's estimated future consumption of fuel oil.

The difficulties of the present situation are on the whole unlikely to be prolonged. In the United States, Mr. R. G. Follis, chairman of the Standard Oil Company of California, estimated that next year's demand in the United States would be 3 per cent. higher than in 1956 when the increase was less than 1 per cent. Mr. Follis based his estimates simply on population growth and on the expectation that temperatures would be lower. In Italy, E.N.I. (Ente Nazionale Idrocarburi) of Rome (see following note) report considerable expansion during the past year and unabated demand during the current year, during which they expect demand to increase at a faster rate than during 1957. Viewed as a whole, the oil position appears very sound and any setback experienced this year is unlikely to be very protracted. The eagerness with which the British Petroleum Company's recent issue was taken up and over-subscribed many times suggests that the investing public shares the same optimistic view.

Italian Oil Concessions

The activities of the Italian state-controlled E.N.I. group have recently become widely known outside Italy. Through a convention signed with the National Iranian Oil Company, E.N.I. have been hoping to secure oil concessions in various ports of the Middle East for several years. They have also been operating in Spain, North Africa and Somaliland. In 1953 E.N.I. secured a lease on an oilfield in the Sinai Peninsula which has developed into the Oriental Oil Company under Italian management. The existence of these holdings was largely responsible for the highly conciliatory attitude of the Italians during the Suez crisis. Other E.N.I. concessions are to be found in the Lebanon, Pakistan and Morocco. Nearer home S.A.I.P., a member of the E.N.I. group equally shares control of the Interfor company with the French Société Nationale des Pétroles.

These activities all fall short of the newly signed Iranian concession. This means that for the first time the Italians have a footing in the Middle East alongside the British, Americans, French and Dutch. Furthermore, Italy now has the chance to cover its own oil needs without buying from outside producers.

With all this activity abroad it is not surprising that E.N.I. are to cut down on their purely Italian activities. The Minister of Industry and Trade have announced that the concession to prospect for oil and natural gas in the Po valley is to be revised. This was previously an E.N.I. monopoly and it was in developing its natural gas that Signor Mattei made his reputation. It has been decided to allow both Italian and foreign private companies to prospect and develop the unexploited sections of the Po Valley and other "likely areas" throughout the country. In view of the high output achieved by E.N.I. in the Po Valley it is doubtful if there is much undiscovered oil or methane. This being so, official policy is presumably to let the foreigners and private concerns spend their money rather than to pour the taxpayers lire down the boreholes.

Mechanisation Has Prospered

The J. H. Fenner group of companies, manufacturers of transmission and mechanical handling equipment, have experienced a very good demand for their products during the year ended August 31. Profit margins were lower but turnover greatly increased. Net profits were 5 per cent. higher than the previous year, but the chairman told shareholders that they were "moving into a situation where, in some of the lines we make, there is certain to be over-production." They are confident, however, that their ability to produce efficiently and to continue to lead their field technically will ensure a "reasonable demand" for their products. One of the newest developments is by the Manufacturers' Equipment Company, the latest of the group's subsidiaries. They manufacture a range of permanent and portable packaged conveyors and mechanical handling equipment under licence from the Rapids-Standard Company in Grand Rapids, U.S.A., including equipment for the automatic handling and sorting of letters at post offices.

The mechanisation of mining, whether of coal or oil, has prospered in the United States, during the year ended last September, at the highest level yet encountered. One of the largest firms making machinery and equipment in this field, the Joy Manufacturing Company of Pittsburgh, effected an increase of over 8 per cent. in turnover and one of 4 per cent. in trading profits. Their world sales, including those of subsidiaries (which include Joy-Sullivan in this country) totalled 149 million dols. compared with 134 million dols. last year.

But Joy Manufacturing, like J. H. Fenner, foresee the end of the mechanisation boom. "As we enter the new year," said their president, "it is evident that many businesses are off from the high levels of the preceding twelve months. It now appears that Joy's operations may be similarly affected." There is the same emphasis on rising costs, particularly labour costs, the same search for greater operating efficiencies and the same concern with finding new products. Only in this manner—they have entered the nuclear and missile fields during the year—do they expect to maintain their momentum.

New Life for Copper

The copper fabricating industry is making great efforts to gain new markets and make up the ground lost to other materials during the years of acute shortage and soaring prices. Sir Ronald Prain, chairman of Rhodesian Selection Trust, told an informal shareholders' meeting last week that at one end of the scale there were uses lost to other metals which were not likely to be regained whatever price differentials might be seen; at the other end copper usage for many purposes was assured irrespective of the price. But in between there was a critical "grey" band which potentially could account for 8 per cent. of the world's present production, equivalent to something like 250,000 tons a year. Everything was being done to stimulate production but the immediate outlook remained uncertain, largely because the present business climate for commodities was unfavourable but also because prices were allowed to go too high. The period of £170 a ton copper is a temporary one but a wonderful opportunity to regain lost markets and develop new ones.

In this country the Copper Development Association are doing a great deal to stimulate demand. One of their latest activities concerns small-bore central heating, where water is forced through ⅝ in. pipe by a circulator—generally a glandless pump—to ensure efficient heating throughout the installation. There is even a possibility of using ¼ in. pipe and therefore of competing with steel on a cost per foot basis. Considerable economies in the cost of installation—up to 50 per cent. compared with orthodox steel pipe—make this system of central heating highly competitive and particularly suitable for installation in existing houses where the piping can be laid almost as electric cable, with a minimum of interference with the structure of the house or building. Many interested parties are promoting the new system and providing installation courses for heating engineers and master plumbers. The copper fabricating industry look to demand from this source to take up or even exceed the fall expected to result from the reduction in the housing programme.

The proposed merger of the Yorkshire Copper Works with the Metals Division of I.C.I. will greatly strengthen the latter's position in the copper-tube market. The booklet published by them entitled "Invitation to a Housewarming," points out the advantages of forced-circulation small-bore central heating. Copper pipes, which offer a very low resistance to the flow of water, are in a very strong competitive position. This new market could exceed the total copper-pipe consumption in housing and is one of the largest potential outlets discovered in recent years.

Bank Review Season Opens

The first annual reviews put out by the big banks are fairly orthodox in their comments on the events of 1957. As would be expected they are concerned so far mainly with the effect of the increase in the Bank Rate last September. This event looms so large in their comments that such matters as the Suez crisis in the first half of the year and the remarkable stability of industrial output in many sectors, have received little or no comment. Mr. A. W. Tuke, the chairman of Barclays Bank Limited, is something of an exception to these for he finds a connection between Suez and the speculation against the pound last autumn. His opinion is that speculators against sterling saw in the joint political isolation of Britain and France in the first half of the year an economic counterpart in the second half of the year. They may have thought, in Mr. Tuke's view, that the fortunes of the franc and the pound were much more closely connected than is indeed the case.

There is no doubt that speculators under-estimated the strong balance of payments position of sterling in 1957 and the forces at work in the United Kingdom economy making for stability in spite of the pressure of economic and political events. The bank chairmen draw attention to the fundamentally healthy position of the country. So far as the future is concerned the bank chairmen so far are content to congratulate the Government on its sterner economic policy and there is some regret at the resignation of Mr. Thorneycroft. None as yet seems unduly concerned at the slowing down in the capital-goods industries or the continuing threat of labour troubles. It will be interesting to see if any of the chairmen yet to issue their statements make any last minute adjustments to their opinions if labour relations worsen or capital investment further deteriorates.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Electrical Installations in Large Dock Areas," by Maurice Rundle. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Thurs., Jan. 30, 6.30 p.m.*

British Institution of Radio Engineers

MALVERN
Annual General Meeting. "Digital Computers," by R. Deighton. South Midlands Section. College of Electronics, Malvern. Fri., Jan. 31, 7 p.m.

British Interplanetary Society

LONDON
"Meteoric Hazards to Space Flight," by Dr. N. H. Langton. Caxton Hall, off Victoria-street, S.W.1. Sat., Feb. 1, 6 p.m.

Building Centre

LONDON
Films "Copper Flashings" and "Copper Weatherings." Exhibited by the Copper Development Association. Wed., Jan. 29, 12.45 p.m.

Chemical Society

CAMBRIDGE
"General Education of the Scientist," by Sir Eric James. Cambridge Branch. University Chemical Laboratory, Lensfield-road, Cambridge. Fri., Jan. 31, 8.30 p.m.
DUNDEE
"Hydrocarbon Complexes of the Transitional Metals," by Professor G. Wilkinson. St. Andrews and Dundee Branch. Chemistry Department, Queen's College, Dundee. Tues., Jan. 28, 5.15 p.m.
EDINBURGH
"Recent Developments in Polymer Science," by Professor G. Gee. Edinburgh Branch. Biochemistry Lecture Theatre, Teviot-place, Edinburgh. Tues., Jan. 28, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Structure of Flames," by Dr. J. W. Linnett. Newcastle and Durham Branch. Chemistry Department, King's College, Newcastle-upon-Tyne. Fri., Jan. 31, 5.30 p.m.

Illuminating Engineering Society

BIRMINGHAM
"Prescribing for Seeing," by M. L. Berson. Birmingham Centre. Regent House, Colmore-row, Birmingham. Fri., Jan. 31, 6 p.m.
HULL
"Chance and Vision," by D. L. Smare. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., Jan. 28, 6.30 p.m.*
LEEDS
"Chance and Vision," by D. L. Smare. Leeds Centre. Lighting Service Bureau, 24 Aire-street, Leeds 1. Mon., Jan. 27, 6.15 p.m.*
LEICESTER
"Modern Applications of Plastics to Lighting Fittings," by P. H. Collins. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., Jan. 27, 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Trade Effluent Treatment," by J. Lakin. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Jan. 31, 7.30 p.m.
CARDIFF
"Application of Plastics in Industry," by G. W. Bowley. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Jan. 28, 7.15 p.m.
LEEDS
"Ferrybridge 'B' Power Station," by W. H. Dunkley. West and East Yorkshire Branch. The University, Leeds. Mon., Jan. 27, 7.30 p.m.
SHEFFIELD
"Industrial Law and the Engineer," by H. Peter Jost. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Jan. 30, 7.30 p.m.

Institute of Fuel

NOTTINGHAM
"Integration of Power Supplies," by E. F. Schumacher. East Midland Section. Gas Board's Showrooms, Nottingham. Thurs., Jan. 30, 6.15 p.m.

Institute of Marine Engineers

LONDON
"Super-Structure Design in Relation to the Descent of Funnel Smoke," by E. Ower and Dr. A. D. Third. Tues., Jan. 28, 5.30 p.m.*

Institution of Chemical Engineers

BIRMINGHAM
Annual General Meeting. "Choice of Materials for Sugar-Refining Plant," by H. M. Peacock (with film). Midlands Branch. Midland Institute, Paradise-street, Birmingham. Sat., Feb. 1, 2.30 p.m.

Institution of Civil Engineers

LONDON
Formal Discussion on "The Disposal of Towns' Wastes," to be opened by W. Fillingham Brown, J. C. Wylie, G. E. G. Mattingly and J. Longwell. Tues., Jan. 28, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"An Inquiry into the Specification of Transistors," by F. F. Roberts. Radio and Telecommunication Section. Mon., Jan. 27, 5.30 p.m.*
Symposium on "Long-Distance Propagation Above 30 Mc/s." Radio and Telecommunication Section. Tues., Jan. 28, 10 a.m., 2.30 p.m. and 5.30 p.m. (Registration forms on application.)
"Laboratory and Field Tests on 132-kV Condenser Bushings," by J. L. Douglas and A. W. Stannett. Supply Section. Wed., Jan. 29, 5.30 p.m.*
LEEDS
Discussion on "The Teaching of Electrical Installation Work." North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 28, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Recent Developments in Medium Voltage High-Breaking-Capacity Fuse Links," by R. H. Dean. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 27, 6.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Heat and Power Surveys," by H. H. Grattidge. Tues., Jan. 28, 6.30 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Applications of the Three-Port Valve to Heating and Air-Conditioning Plant," by J. S. Smith. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Jan. 28, 6.30 p.m.

Institution of Highway Engineers

NORWICH
"Quarrying," by J. M. Dixon. East Anglia Branch. Assembly House, Norwich. Tues., Feb. 4, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "To What Extent Should Students be Penalised for Bad English in National Certificate Examination Papers?" Education Group. Wed., Jan. 29, 6.45 p.m.*
"Some Experimental Studies of the Mixing Processes and Flow Configurations in Two-Cycle Engine Scavenging," by W. Rizk. Meeting in conjunction with the Internal Combustion Engine Group. Fri., Jan. 31, 6 p.m.*
ABERDEEN
Thomas Lowe Gray Lecture on "Machinery for Cross-Channel Passenger Ships," by E. L. Denny. Scottish Branch. Robert Gordon's College, Aberdeen. Fri., Feb. 7, 7.30 p.m.
BEDFORD
"Design and Production of Agricultural Machinery," by H. H. Dawson. Eastern Branch. Dujon Restaurant, Bedford. Tues., Jan. 28, 7.30 p.m.
GLASGOW
Thomas Lowe Gray Lecture on "Machinery for Cross-Channel Passenger Ships," by E. L. Denny. Scottish Branch. Royal College of Science and Technology, Glasgow. Thurs., Feb. 6, 7.30 p.m.
LIVERPOOL
"The Steam Catapult," by Commander C. C. Mitchell and Captain Q. H. Paterson. North Western Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Jan. 30, 6.30 p.m.
MANCHESTER
"Commercial Applications of Electronic Computers," by J. R. Stockley. North Western Industrial Administration and Engineering Production Group. Engineers' Club, Albert-square, Manchester. Thurs., Jan. 30, 6.45 p.m.
RUGBY
Automobile Division chairman's address on "Experience During 40 years of Automobile Design," by A. G. Booth. Midland Branch. College of Technology and Arts, Rugby. Tues., Jan. 28, 6 p.m.
SHEFFIELD
"Principles and Applications of Spark Machining" with practical demonstration, by D. W. Rudorff. Yorkshire Branch. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Wed., Jan. 29, 6.30 p.m.

Institution of Production Engineers

LINCOLN
"The Centre-Spinning Process as Applied to the Manufacture of High-Duty Components," by A. E. Thornton. Lincoln Section. Ruston Club, Lincoln. Thurs., Jan. 30, 7.30 p.m.
MANCHESTER
"Plastics Material in Engineering," by A. P. Clark. Manchester Section. Reynolds Hall, College of Science and Technology, Sackville-street, Manchester. Mon., Jan. 27, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Technical Training and Professional Status," by the President, Lord Halsbury. Northern Region. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Jan. 31, 7 p.m.
SHREWSBURY
"High-Speed Press Work," by J. A. Grainger. Shrewsbury Section. Technical College, Shrewsbury. Wed., Jan. 29, 7.30 p.m.
STOKE-ON-TRENT
"Nuclear Power and Its Effect on the Production Engineer," by I. Munro. Stoke-on-Trent Section. Grand Hotel, Hanley, Stoke-on-Trent. Mon., Jan. 27, 7.30 p.m.

Junior Institution of Engineers

LONDON
"The Clean Air Act and the Engineer," by E. C. Rogers. Fri., Jan. 31, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Some Historical Notes on the Contributions of Manchester to the Development of Science and Engineering," by Dr. H. J. Axon. Engineers' Club, Albert-square, Manchester. Fri., Jan. 31, 6.45 p.m.

Manchester Metallurgical Society

MANCHESTER
"Behaviour of Metals at High Temperatures," by Dr. N. P. Allen. Central Library, Manchester. Wed., Jan. 29, 6.30 p.m.

Modular Society

LONDON
"Modular Co-ordination in Building and European Free Trade," by Ernst Skarum. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Mon., Jan. 27, 7.30 p.m.

Non-Destructive Testing Society of Great Britain

LONDON
"Ultrasonics for Non-Destructive Testing," by H. W. Taylor. London and Home Counties Branch. 32 Welbeck-street, W.1. Fri., Jan. 31, 7 p.m.

Reinforced Concrete Association

GLASGOW
"The New Iron and Steel Plant of Colvilles Ltd., at Ravenscraig, Motherwell," by N. O. Kendal. Scottish Branch. St. Enoch Hotel, Glasgow. Tues., Jan. 28, 6.30 p.m.*

Royal Aeronautical Society

LONDON
"Power Controls for Supersonic Aircraft," by G. Selwood. Tues., Feb. 4. *Cancelled.*

Royal Institution

LONDON
"Gemstones," by Sir Lawrence Bragg. Fri., Jan. 31, 9 p.m.

Royal Meteorological Society

EDINBURGH
"Radiation Meteorology and Some of Its Applications," by M. J. Blackwell. Scottish Centre. Department of Natural Philosophy, The University, Drummond-street, Edinburgh. Fri., Jan. 31, 5 p.m.*

Royal Society of Arts

LONDON
"The Marriage of Art and Science," by Professor A. R. J. P. Ubbelohde. Wed., Jan. 29, 2.30 p.m.

Royal Statistical Society

LONDON
"Mortality of Miners," by Dr. D. D. Reid. Medical Section. Westminster Medical School, Horseferry-road, S.W.1. Tues., Jan. 28, 5.30 p.m.
SHEFFIELD
"The Installation of a Quality Control System," by D. C. Webb. Sheffield Industrial Applications Group. Y.M.C.A., 49 Fargate, Sheffield, 1. Thurs., Jan. 30, 7 p.m.*

Royal United Service Institution

LONDON
Film Display "Voyage to Virginia." Wed., Jan. 29, 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Production of Continuous Stainless Steel Sheet," by J. A. Campbell. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 28, 7 p.m.

Society of Instrument Technology

LONDON
"Digital Codes in Data-Processing Systems," by M. P. Atkinson. Data Processing Section. Manson House, Portland-place, W.1. Tues., Jan. 28, 7 p.m.*
CHELTENHAM
"Process Control in the Chemical Industry," by P. J. K. Simpson. Cheltenham Section. Rotunda, Cheltenham. Fri., Feb. 7, 7.30 p.m.
CHESTER
"Industrial Applications of Radio Isotopes," by H. A. Tapsfield. Chester Section. 5 King's Buildings, King-street, Chester. Wed., Jan. 29, 7 p.m.
FAWLEY
"Application of Modern Techniques to Automation," by J. Loxham. Fawley Section. Copthorne House, Fawley, Hants. Fri., Feb. 7, 7 p.m.
GLASGOW
"Plant Analysis," by J. McMillan. Scottish Section. Scottish Building Centre, 425 Sauchiehall-street, Glasgow. Wed., Jan. 29, 7.15 p.m.

Women's Engineering Society

LONDON
"Food Instrumentation," by C. G. Barlow. London Branch. Offices of the Central Electricity Generating Board, Winsley-street, near Oxford-circus, W.1 (evening entrance is in East-castle-street). Tues., Jan. 28, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
Modular Society, 22 Buckingham-street, London, W.C.2. (TRAfalgar 4567.)
Non-Destructive Testing Society of Great Britain, 2 Tomswood-terrace, Barkingside, Essex. (HAInault 5488.)
Reinforced Concrete Association, 94–98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Metals and Materials

INTERNATIONAL STANDARDS FOR RUBBER TESTING

The seventh meeting of Technical Committee No. 45 on Rubber of the International Standards Organisation (usually abbreviated to I.S.O./T.C.45) was held in Zürich from September 30 to October 5, 1957, to consider further the international standardisation of methods for testing rubber. Three of the subjects considered at the meeting have been reviewed by United Kingdom delegates, the first, on "Low-Temperature Tests on Rubbers," being the subject of the present article. The two other subjects: "Tests for Rubber-to-Metal Bonding," and "Testing of Antistatic and Conductive Rubber," will be discussed in a forthcoming issue.

LOW-TEMPERATURE TESTS ON RUBBERS

By F. H. Edwards, B.SC.*

Interest in the properties of rubbers at low temperatures was stimulated in the war of 1939-45, since the armed services required rubber goods which would preserve their flexibility in the Arctic regions and in the stratosphere. The subject of low-temperature testing has subsequently received much attention so that a need for standardisation of procedures has become imperative. In 1953 the International Standards Organisation Technical Committee on Rubber (I.S.O./T.C. No. 45) set up a working group under the chairmanship of the United States delegation to investigate test methods.

Prior to discussing these methods of test, some comments regarding the various changes which elastomers undergo when subjected to low temperatures may be helpful. The changes in the elastomer may be due to (1) simple temperature effects; (2) second-order transitions (vitrification); (3) first-order transitions (crystallisation); and (4) effects associated with plasticisers.† The extent of these changes depends on the nature of the material and the time and temperature of exposure.

Simple temperature effects are usually manifested by increases in modulus, stiffness and hardness. As the temperature is lowered, resilience may go through a minimum and then increase to a maximum at some temperature above the second-order transition. Such changes are complete when the test specimens reach thermal equilibrium.

Second-order transitions usually take place quickly within a temperature range of a few degrees. Ordinarily, elastomers become unserviceable owing to simple temperature effects well above the second-order transition temperature.

First-order transitions are manifested by an increase in modulus or hardness. They may take place soon after thermal equilibrium is reached or only after prolonged exposure. In general, the temperature for maximum crystallisation rate is specific for the base polymer (thus, for natural rubber the temperature is 25 deg. C., and for neoprene GN it is 0 deg. C.) and stretching the specimen usually accelerates crystallisation. Not all polymers are affected.

Elastomers containing high concentrations of plasticisers when subjected to low temperatures may stiffen and become more brittle (or exhibit higher brittle temperature). Time effects not necessarily associated with crystallisation may be observed.

In the United Kingdom only a stiffness test capable of determining the rigidity modulus has been accepted for inclusion in British Standard specification 903. In the United States there is a belief that no single test will provide a suitable evaluation at low temperatures and it is generally agreed that the service for which the rubber item is designed should be the decisive criterion in the ultimate selection of test procedures.

At I.S.O. level four types of test have received consideration on the basis of utility for material specifications rather than for research purposes, namely tests for the determination of stiffness, brittleness, hardness and compression set. At the recent seventh meeting of I.S.O./T.C. No. 45 held at Zürich in October, the first two tests were agreed as suitable for draft I.S.O. proposals to be prepared and circulated. In the cases of hardness and compression set it was reported that inter-laboratory tests would be carried out. The need for dynamic test methods suitable for use at low temperatures was also stressed, but work on this subject has been deferred pending reorganisation of the working groups. In the present article, it is proposed to limit discussion to the tests for stiffness and brittleness.

* Bragg Laboratory, Naval Ordnance Inspection Establishment, Sheffield.

† For a more complete discussion of these effects reference should be made to the American Society for Testing Materials publication No. D 832.

STIFFNESS

The test for stiffness is based (with sundry minor amendments) on the Gehman torsion method described in A.S.T.M. No. D 1053-54T, wherein the stiffness of a small rubber strip of standard dimensions is measured by the effect it produces on a calibrated torsion wire of tempered-spring quality which is twisted through an angle of 180 deg.

The apparatus, which is clamped to a support stand, consists of a torsion head capable of being rotated in a plane normal to the torsion wire. The upper extremity of the wire is fastened to the torsion head and its lower end can be joined by a screw connector to a clamp attached to the upper end of the rubber test piece, the opposite end of the test piece being held in a fixed clamp. The free length of the rubber test piece between the two clamps is maintained at a constant distance in all the tests. A pointer operating over a movable protractor is attached to the lower end of the torsion wire. The test can be conducted at controlled temperatures in liquid or gaseous media which are unreactive with the rubber. A feature of the Gehman apparatus is the rack provided for holding several specimens in the test medium so that successive samples can be tested at a given temperature.

After setting the pointer to zero on the protractor the procedure is to record the angle of twist shown by the pointer ten seconds after the torsion head has been quickly turned through 180 deg. This is performed first at room temperature (25 deg. C.) and it is an essential of the test that the angular reading shall be between 120 and 170 deg. or the test must be repeated with a more suitable calibrated torsion wire. Similar tests are made at the same temperature on the remaining test pieces held in the rack whereupon the liquid bath is reduced to the lowest temperature desired and is held constant for 5 minutes before retesting each test piece. The bath temperature is increased by 5 deg. C. intervals and stiffness measurements made after conditioning the test pieces for 5 minutes at each temperature, the tests being continued until a temperature is reached at which the angular twist is within 5 to 10 deg. of the angle originally measured at 25 deg. C.

For tests in gaseous heat-transfer media, the minimum conditioning period must be increased to at least 10 minutes. Longer times may be required for crystallisation or plasticiser-time studies.

A graph is plotted of the angle of twist (i.e., the twist) against the temperature. The torsional modulus of the test piece at any given temperature is proportional to the quantity:

$$\frac{\text{180 degrees—twist}}{\text{twist}}$$

The relative modulus at any temperature (t), which is the ratio of the torsional modulus at that temperature to the torsional modulus at 25 deg. C., can be evaluated by determining the angles of twist from the experimental graph and substituting them in the above factor thus:

$$\frac{b\,(180—a)}{a\,(180—b)},$$

where a = twist angle at t deg. C., and b = twist angle at 25 deg. C.

Usually the information required is the temperature for which the relative modulus is a multiple of 2, 5, 10 and 100 (designated the T_2, T_5, T_{10}, T_{100} values). This can be ascertained by the use of a table which is given in the text, together with reference to the experimental graph. Alternatively there is an equation available from which absolute values of the torsional modulus of rigidity can be derived.

BRITTLENESS

The I.S.O. test for brittleness to be recommended consists of a modification of that described in A.S.T.M. No. D 746-55T. It represents a procedure for determining the lowest temperature at which rubber compounds do not exhibit brittle failure when subjected to impact under specified conditions. Brittleness temperatures so determined are not necessarily indicative of service performance but are considered as measures of the absolute minimum temperature of usefulness of rubber compositions.

In other words, brittleness temperatures are empirical points, dependent to a large degree upon test procedures and apparatus. To obtain reproducible results all pertinent test variables must be closely specified. For instance the velocity of the impact blow is critical.

The apparatus for the brittleness test, which may be motor-driven or solenoid actuated, is designed to hold the test piece or pieces as a cantilever beam. Up to five test pieces may be tested simultaneously, the clamp and test pieces being immersed for a specified time in the cooling medium, which may be liquid or gaseous and is temperature-controlled. The test pieces are then subjected to a single impact blow delivered by a striking edge of specified form and velocity. New test pieces are used for each impact. After impact the test pieces are examined for failure which is defined as any crack, fissure or hole visible to the naked eye, or complete fracture.

To establish the brittleness temperature, the procedure is to conduct preliminary tests on single test pieces starting at a temperature below the expected brittle point, followed by tests at successively increasing temperatures at intervals of 10 deg. C. until a failure is not obtained. The temperature of the heat-transfer medium is then decreased to the highest value at which a failure was observed and tests then made at successively increasing temperatures at steps of 2 deg. C. Tests are made at each temperature until five consecutive cases of non-failure are observed at one temperature, which is considered to be the brittle point.

The conditioning time of the test piece, at any given test temperature, is specified as from 2½ to 3 minutes when a liquid medium is provided but should be one hour in the case of a gas.

Management

THE ENGINEERING INDUSTRIES

What The Future Holds for the

This is the concluding article in a series of four giving forecasts of the prospects for different sections of industry. The present article deals with the light electrical industry, wires and cables, and with "general engineering," including civil engineering. The first article, in our issue of January 3, dealt with the effects of exports, raw materials and wages on the engineering industry as a whole. The second (January 10) forecast the outlook for five industries—agricultural machinery; locomotives and rolling stock; machine tools; textile machinery; and coal and electricity. Last week, in the third article, three cognate industries were considered: shipbuilding, aircraft and motor-cars.

LIGHT ELECTRICAL INDUSTRY, WIRES AND CABLES

In spite of the intensification of the credit squeeze in 1957 most manufacturers of domestic equipment managed to expand their sales. This resilience was shared by companies in the light electrical industry, as can be seen in the diagrams. With the exception of electric irons, all sections of the electrical industry manufacturing domestic appliances showed an expansion of production in 1957—in many cases a reversal of a downward trend in 1956.

Manufacturers of cables also had a satisfactory year in 1957, despite uncertainties as to the future of capital investment by the nationalised electricity undertakings.

In contrast to home sales, however, exports of domestic equipment, radios and television sets, did not show such a sharp upward trend. Manufacturers of radio and television sets, however, are confident that their export sales will increase in 1958 as a result of new designs displayed at the National Radio Show at Earls Court in September. Companies in this field have come under some criticism during the last year or so for their failure to design for the export market, as a result of which they have been losing orders to French and German manufacturers. This partly explains why exports of complete radio and television sets have fallen, while sales abroad of kits and parts have continued to expand. Germany, on the other hand, sent 200,000 television sets abroad in 1957, compared with 57,000 in 1956. Dutch competition is also becoming intense.

Meanwhile, the radio industry continues to rely for the bulk of its export sales on record players, sound-reproduction equipment, components and communication equipment. On the home market, sales of radio and television sets have been largely maintained by the development of improved models at roughly the same price as the ones they have displaced, and the opening of new television and v.h.f. transmitters. It has been estimated that there are now about 7½ million licensed television sets in British homes, or one to every two households. It has been suggested in many quarters that the rate of expansion of production and sales of television sets must soon tail off and that manufacturers will soon be concentrating on the replacement market. At the same time, increasing sales of record players and radiograms should offset any decline in sales of television sets on the home market during 1958, provided that the Chancellor does not tighten hire-purchase restrictions further in the spring. Since the initial deposit on new sets already stands at 50 per cent., however, further restrictions appear unlikely.

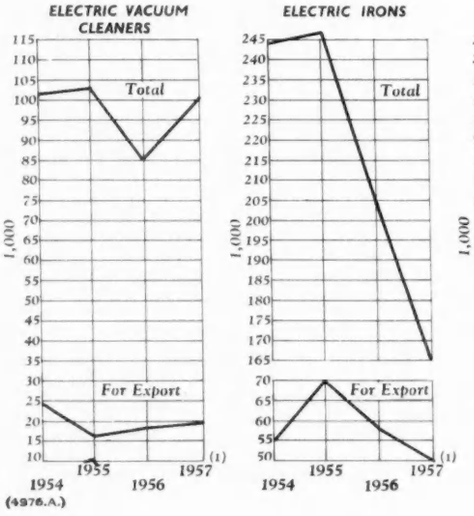
Meanwhile interest has continued to be centred upon technical improvements to radio equipment. The main example of this in recent years has been the increasing use of the germanium transistor, and there were further developments in 1957. Mullards have now concentrated semi-conductor production under one roof at Southampton, and believe that transistors may soon become sufficiently standardised for them to be produced on a large scale. A new company—Semiconductors Limited—has been formed in this country jointly by the Philco Corporation of America and the Plessey Company, to specialise in the manufacture of transistors and other semi-conductors. Another important development in this field was the start of silicon transistors production at the new plant of the Texas Instrument Company at Bedford. While silicon transistors are five times as expensive as germanium transistors, they can be used at temperatures nearly three times higher than germanium and 50 per cent. higher than can safely be allowed for electronic valves. The major factor working against the widespread use of transistors in domestic appliances and radio sets has, of course, been that of price, though present indications are that within the next year or so they should become competitive in this respect with valves, and thus become more widely used in small radio and television sets and other items of light electrical equipment.

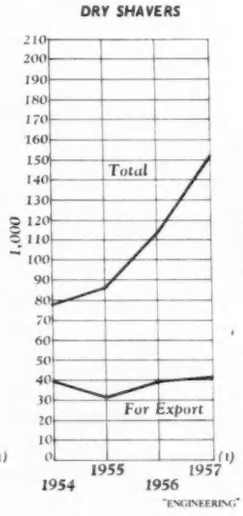
A small item of electrical equipment, sales of which have increased remarkably since the war, has been the electrical dry shaver. Production of dry shavers rose by nearly 35 per cent. in 1957, totalling 1,825,200 units. This compares with only 63,000 sold in 1946. It has been estimated that the potential market for

United Kingdom Exports of Light Electrical Goods and Apparatus and of Telegraph and Telephone Cables. (*Value* £1,000)

—	1955	1956	1957*
Electronic valves and radio, television, and sound reproducing apparatus	28,233	33,622	34,457
Telephone and telegraph apparatus	15,826	19,706	22,601
Electric light bulbs and tubes	2,508	2,633	2,696
Electric light apparatus and appliances	5,131	5,628	5,213
Batteries, primary, complete	3,471	4,674	4,650
Accumulators, complete	3,343	3,949	3,388
Electrical cooking and heating appliances	4,963	4,633	4,002
Electrical instruments	4,799	4,960	5,810
Electromedical apparatus	1,372	1,630	1,336
Refrigerating machines	14,482	14,811	14,767
Vacuum cleaners	1,575	1,696	1,763
Total	85,703	97,942	100,683
Telegraph and telephone cables and wires:			
Submarine	862	2,050	5,586
Other	6,393	10,207	11,474
Other descriptions of cables:			
Cotton, silk or artificial silk insulated	591	581	442
Enamel, glass or asbestos insulated	932	1,224	1,098
Paper insulated	9,739	10,505	9,294
Rubber insulated	5,753	6,477	6,510
Thermoplastic insulated	1,052	1,762	2,253
Other	2,458	2,569	2,069
Total	27,780	35,375	38,726

* Partly estimated.

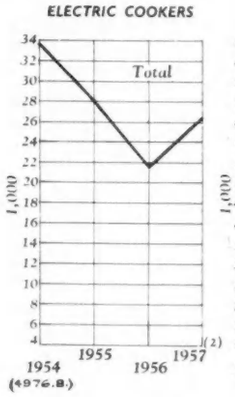


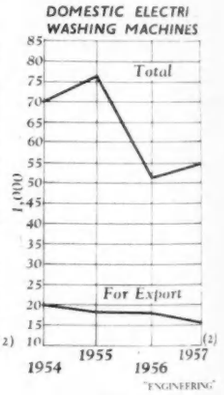


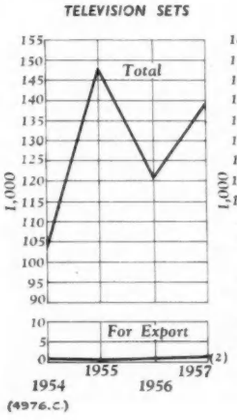
Average monthly output of domestic electrical appliances in the United Kingdom (Thousands).

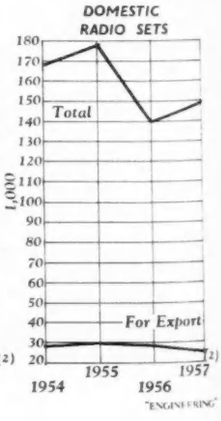
(1) Estimated from first six months

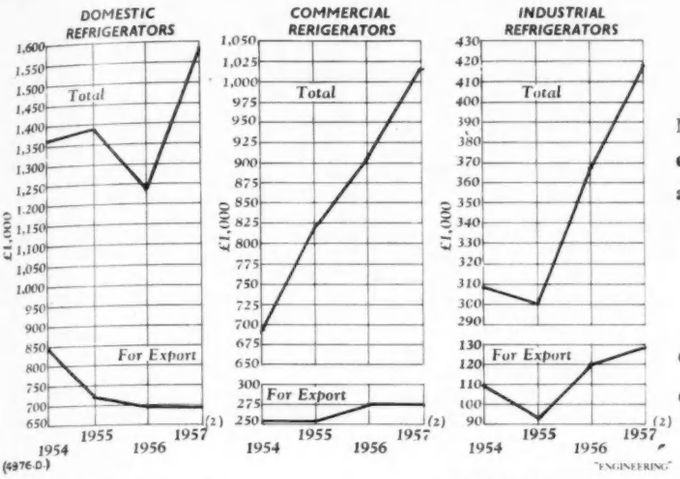
(2) Estimated from first six months







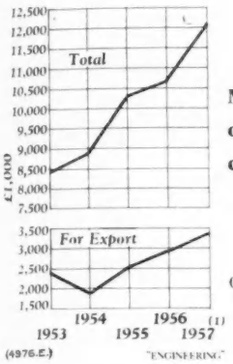




Monthly average of domestic, commercial and industrial refrigerators (£1,000).

(1) Estimated from first six months

(2) Estimated from first nine months



Monthly average output of wires and cables in the United Kingdom (£1,000).

(1) Estimated from first eight months

dry shavers in this country is well in excess of 17 million units, and the large manufacturers should again do well in 1958. The increase in home sales of such shavers has, unfortunately, not been matched by a corresponding increase in exports, which have remained virtually static for some years at around 480,000 units.

Most manufacturers of domestic refrigerators, cookers, washing machines and vacuum cleaners had a good year in 1957. The General Electric Company opened a new plant at Inverness late in 1957 which is to manufacture between 4,000 and 5,000 electric cookers a year, and to employ 30 people. Bendix Appliances introduced their new Gyrometric washing machine in 1957 and claimed immediate success in the export market with an order valued at £500,000 for 5,000 machines from New Zealand.

Companies engaged in the electronics industry as a whole are reaping some of the benefits of the increasing emphasis in the Government's defence policy on guided missile development, and most large manufacturers in this field seem to be assured of another good year in 1958. Mr. Aubrey Jones, Minister of Supply, said in September, 1957, when he was opening the Radio Show, that the electronics industry was now playing a bigger part in the manufacture of guided missiles than the aircraft industry. For companies in the light electrical industry engaged on the manufacture of electronic components, this is a fortunate development since many of the same companies are also engaged in the production of conventional electrical aircraft components, the demand for which is likely to fall sharply as a result of defence cuts.

Production of electric wires and cables rose by 12 per cent. in 1957, while exports expanded by a further 10 per cent., thus continuing the prosperity of the cable industry which has been a feature of recent years. Most major cable manufacturers showed a further increase in profits in 1957, despite stock losses due to the sharp fall in the price of copper and the effects of the investment squeeze on the expansion plans of the nationalised electricity authorities. British cable manufacturers continued to secure valuable contracts abroad. British Insulated Callender's Cables announced in October, 1957, that they had gained a contract for the installation of a 3·5 million dol. circuit in a submarine power cable line to be constructed between Vancouver Island and the mainland of British Columbia for the British Columbia Electric Company. B.I.C.C. also secured a valuable order from the Uganda Electricity Board for the supply and erection of distribution lines between Nityana and places near the Kenya border. Of the 600 miles of lines, B.I.C.C. are to erect 320 miles.

Foreign competition has, however, intensified, and a large proportion of the Uganda order went to the Italian cable concern, Electra S.p.A., who will erect 280 miles of distribution lines in Uganda. Competition from overseas countries is likely to intensify still further in the coming year. Japanese cable manufacturers are becoming interested in Far Eastern projects and it was announced late in 1957 that a factory is to be constructed at Trippunithura in India as a joint project of Indian interests and the Furuwaka Electric Company of Tokyo. This factory is expected to start production late in 1958. At the same time it was discouraging to note that B.I.C.C. felt compelled to give up their control of the India Cable Company, because of the introduction of new taxation legislation by the Indian Government; B.I.C.C., however, have retained some holdings in this company. Meanwhile, the output of the State-owned Hindustan Cables plant was expected to be increased to 1,000 miles of cable a year by the end of 1957, or about double the previous year's total. By the end of 1957, this factory was able to meet all the requirements of the Posts and Telegraphs Department in India.

Any fall in orders for cables from the electricity authorities at home is likely to be in part offset by the development of two new transatlantic submarine telephone cables. Some of the contracts for the first of these two projects have already been placed. These are for the new transatlantic telephone cable to be laid between America and France by the American Telephone and Telegraph Company, work on which will be started in 1959. The system, when completed, will provide for 36 simultaneous telephone conversations. The installation will be on roughly the same lines as the present transatlantic telephone cable, and will include two cables, one each for outward and incoming telephone conversations. The British share of the cable, covering 2,200 nautical miles, is to be supplied by Submarine Cables Limited and the order is worth £3 million. The remaining contracts will be placed with French and German companies.

In addition to the American Telephone and Telegraph Company's project, there is also to be a joint scheme by Cable and Wireless Limited and the Canadian Overseas Telecommunications Corporation. This project envisages a marked change in design, since one cable will be constructed to carry both outward and inward conversations by means of two-way repeaters. It will carry 60 conversation channels as compared with 35 in the line at present used, and will cost about £8 million compared with the £15 million spent on the present line, which was a joint Anglo-United States-Canadian project. The new Cable and Wireless cable will have a diameter of $\frac{1}{2}$ in. as compared with about 1 in. for the present cable, and strength will be obtained by a non-twisting steel core instead of outside armouring. It is thought that the bulk of the contracts for this single cable communication will go to British companies. The cable itself will be made at the Ocean Works of Submarine Cables, and Standard Telephones and Cables Limited will provide the deep-water amplifiers necessary for voice boosting. The cable is expected to be completed in 1961.

What the Future Holds for GENERAL AND CONSTRUCTIONAL ENGINEERING

The "engineering industry" comprises such a wide variety of individual products and types of product that detailed discussion of each is impossible in the space available for this survey. It is possible only to give output and export figures for certain selected products and to discuss briefly the situation in a few of these industries.

In general, exports of the products listed in the Table (page 116) have increased by a reasonable margin during 1957. The fields in which this expansion has taken place are cranes, hoists and other lifting machinery; gas and chemical machinery; office machinery; and certain categories of scientific instruments.

The decline in both production and exports of pedal cycles which started in 1956 continued during 1957. Production for 1957 is estimated to have amounted to less than 70 per cent. of the numbers produced in 1955. Exports in terms of value have dropped from £20·9 million to £14·2 million between 1955 and 1957. There has been a very slight increase in home demand, but this has been insufficient to offset the continued decline in exports. Cycle exports to the United States dropped severely in 1956 and this decline has continued at a lower rate during 1957. The United States remained the most important single customer, though exports to the British African territories are considerable and those to Rhodesia and Nyasaland approach the present level of exports to the United States. There appears, however, to be no lack of confidence in the cycle industry. The reorganisation and regrouping which took place in 1956 has continued, and about 80 per cent. of United Kingdom cycle production is now concentrated in the hands of two large organisations, the British Cycle Corporation and Raleigh Industries. The confidence of the industry is perhaps reflected in the fact that Raleigh, towards the end of the year, opened a new factory which was stated to expand its former plant capacity by 50 per cent. It is still felt that there is a very considerable potential market in the underdeveloped countries. This has been the feeling for some time, but the export statistics do not so far show much sign of expansion in this field.

In contrast to cycles, the office-machinery industry continues to expand. Exports, which have been rising steadily for a number of years, rose again in 1957 to an estimated figure of very nearly £19 million. Production in most categories with the exception of accounting machinery rose by a considerable margin. The accounting-machinery field is rapidly being overshadowed by the steadily growing production of digital computers, both for scientific and business purposes. It has been estimated that something

Continuing Management

in the order of £25 million is likely to be spent on computers in this country in 1958.

Australia remains the largest single customer for United Kingdom office machinery and exports in 1957 both to that country and to New Zealand do not appear to have been affected very greatly by the transport difficulties in the early part of the year. Exports to the United States rose to a higher figure than that achieved in 1955, reversing the downward trend in 1956. Exports to Canada continued to rise.

The value of building and civil engineering work done in the United Kingdom in the first nine months of 1957 was £1,608 million compared with £1,543 million for the corresponding period of 1956. It may be estimated that the total value of work done in 1957 rose by between 3 and 4 per cent. over that for 1956. However, taking into account increased prices, the volume of output probably rose little. This has been in accordance with expectations. The value of industrial building plans approved in 1957 shows a continuing slight decline from 1956, a year in which approvals were already at an appreciably lower level than in 1955. Once again, therefore, it is probable that the volume of building and civil engineering work carried out at home in 1958 will show little change over that for 1957. Employment in the building and civil engineering industry has remained approximately constant during 1957 at a level very slightly below that obtaining in 1956.

Overseas work done by British contractors increased to £94 million in the year ending March 31, 1957, compared with £87 million for the previous year. At the same time new contracts obtained declined from £109 million to £92 million. The main reason advanced for this decline was the Suez crisis. The decline in new contracts obtained took place, in fact, in the sterling area; in the dollar area the situation was much more encouraging. In the year 1956-57, contracts valued at £29 million were obtained in Canada, compared with £20 million in the previous year, and it is believed that there is scope for further increases. There has over the past few years been a shifting emphasis in foreign competition experienced by United Kingdom contractors, from questions of cost to the provision of credit facilities. Some foreign contractors, in particular from Germany, Russia and the United States, can offer extensive credit facilities which have a particular attraction in the case of under-developed countries.

In this country there have been a number of interesting and large new projects set under way during 1957. Perhaps the most important of these is the proposed Forth road bridge. The estimated cost of this project is £15 million and it is hoped to have it completed by December, 1962. It has been announced that tenders for construction of the foundations and cable anchorages would be invited early in 1958.

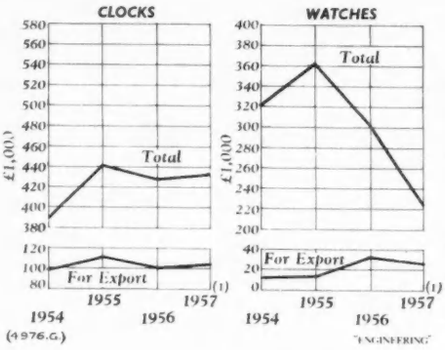
There has also been revived interest in the construction of a Channel tunnel, the value of which would be greatly enhanced by the setting up of a Free Trade Area. This project would cost more than £100 million, but any early action appears unlikely. If the Free Trade Area is established increased trade between the United Kingdom and the Continent is likely to result in a demand for considerably expanded ferry services which permit direct delivery by road or rail to destinations.

The home market for earth-moving and road construction machinery is, of course, affected largely by the road building programme. So far as can be gathered from official statements, the programme of improvement and extension of the arterial road system of the United Kingdom, now started, is not to suffer from the latest cuts in Government expenditure. Though overall expenditure on transport systems will suffer to some extent, any cuts are likely to fall on the railways rather than the roads.

Towards the end of 1957, the re-newed credit restrictions began to have a serious effect on orders for excavators and other types of contractors' plant. The production of earth-moving machinery with some slight setbacks has been rising steadily for the past two or three years. During 1956, the steady though slight rise in output was largely accounted for by higher exports. This pattern was not repeated last year. In the early part of 1957, exports were high, but by September had fallen to about 75 per cent. of the previous year's figures. The fall in home demand has been partly due to higher interest rates but has also been affected by the doubtful prospects of contractors, following cuts in local authority spending programmes. The trends shown in the diagrams of output of civil engineering and contracting plant may therefore be slightly misleading, in that the 1957 figures are based on a six months' annual rate. They suggest, however, an increase in output for 1957, with the exception of concrete mixers. It is probable, however, that this expansion has levelled off to some extent in the last quarter of 1957 and that 1958 output will show only a modest increase, or possibly even a slight fall if export demand continues weak.

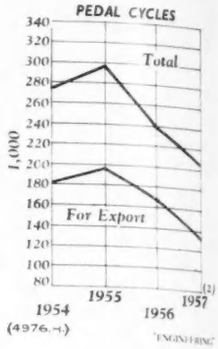
In spite of these doubts and the difficulty of forecasting the outlook, manufacturers of some forms of equipment at least are continuing their modernisation and expansion programmes. The Caterpillar Tractor Company, who acquired the physical assets of the Birtley Company towards the end of 1956, have announced a five-year modernisation plan for the works at Birtley. Their new works near Glasgow will also begin producing soon. The International Harvester Company hopes within a few years to be building 3,000 crawler tractors a year and current expenditure on new plant and machine tools will bring their investment at their Doncaster plant to almost £8 million.

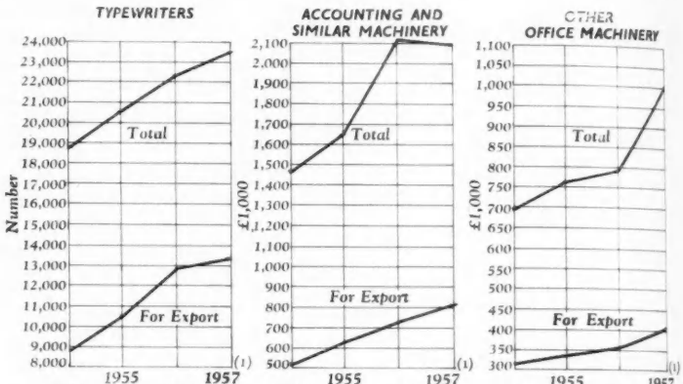
The expansion of American companies' sub-



Average output per month of clocks, watches and bicycles in the United Kingdom.

(1) Estimated from first eight months
(2) Estimated from first nine months





Monthly average output of office machinery in the United Kingdom.

(1) Estimated from first nine months

United Kingdom Exports of Some Industries Classified as "General Engineering" (Value £1,000)

—	1953	1954	1955	1956	1957*
Air and gas compressors and exhausters	4,986	5,172	5,398	6,277	6,891
Boot and shoe machinery	885	958	1,166	1,036	1,170
Cement-making machinery	1,445	989	1,137	1,016	1,463
Centrifugal drying machinery	817	709	877	781	1,055
Concrete mixing machinery	1,301	1,117	1,597	1,775	1,552
Condensers	788	890	847	747	1,042
Cranes, hoists and other lifting machinery	12,978	13,713	12,370	14,292	15,750
Dairy machinery	1,122	1,382	2,009	2,373	1,703
Excavating and similar digging machinery	16,111	14,893	18,902	22,658	22,419
Fans, power driven	2,715	2,574	2,795	3,408	3,600
Food preparation and sterilising machinery	4,538	4,238	4,533	5,351	5,077
Furnace plant	1,473	1,404	3,190	2,538	3,370
Gas and chemical machinery	2,229	2,487	2,807	2,235	3,623
Grain-milling machinery	2,059	2,041	2,284	2,762	2,238
Hydraulic machinery	913	789	1,250	1,270	1,007
Laundering and dry-cleaning machinery	6,030	6,757	7,485	7,376	6,944
Lawn mowers	1,542	1,827	2,033	1,691	1,617
Office machinery	11,094	12,192	14,787	16,321	18,898
Packing, packeting and labelling machinery	2,883	3,523	4,819	5,675	5,902
Portable power tools	3,794	4,175	5,302	5,994	6,183
Printing and book-binding machinery	8,509	9,061	9,848	10,300	10,029
Pulp and paper-making machinery	4,119	4,086	4,081	3,221	2,948
Pumps	13,496	13,250	13,803	16,143	16,677
Road rollers	1,610	1,658	2,086	2,454	2,395
Sewing machines and parts	7,297	8,046	9,699	10,665	10,751
Sugar making and refinery machinery	2,426	3,656	2,270	2,352	2,166
Tobacco and cigarette-making machinery	3,385	4,273	3,842	3,520	4,017
Weighing machinery	1,606	1,495	1,707	1,892	1,892
Welding machinery	2,421	1,797	1,895	2,530	2,666
Woodworking machinery	2,077	1,865	2,128	2,394	1,800
Ball and roller bearings	3,620	3,864	4,526	5,411	6,001
Opthalmic instruments	698	794	78.	616	741
Medical and surgical instruments	1,776	2,071	2,268	2,350	2,425
All other scientific instruments	9,968	11,285	12,926	14,306	17,202
Clocks and watches	1,050	1,342	1,604	1,698	1,958
Total	143,761	150,373	169,046	185,428	195,172

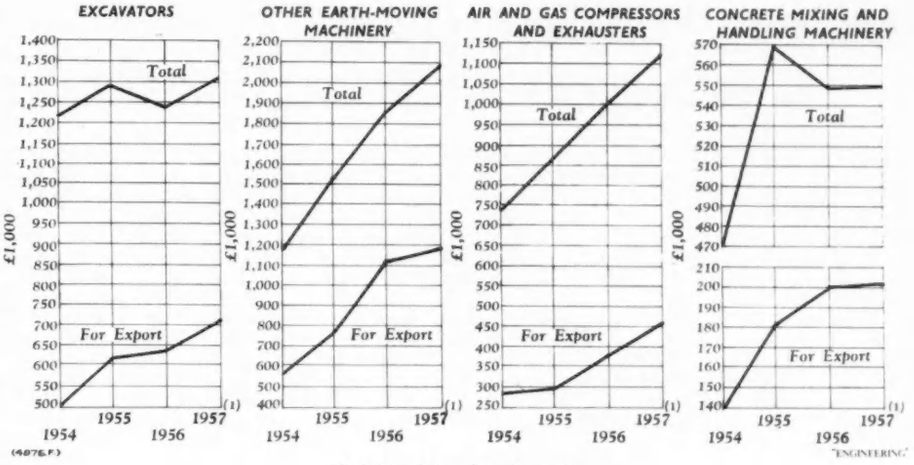
* Estimated from first 9 months

sidiaries in this country continues and is a part of the trend, apparent also in the agricultural machinery field, of American companies transferring production from high-cost producing areas to such countries as the United Kingdom. So far as this country is concerned, this development has the advantage that a high proportion of the equipment is produced for export.

With the exception of a slight decline in the output of fork-lift and other works trucks, the average monthly output of mechanical handling equipment rose appreciably during 1957. Exports of cranes, hoists, and other lifting machinery made an appreciable advance.

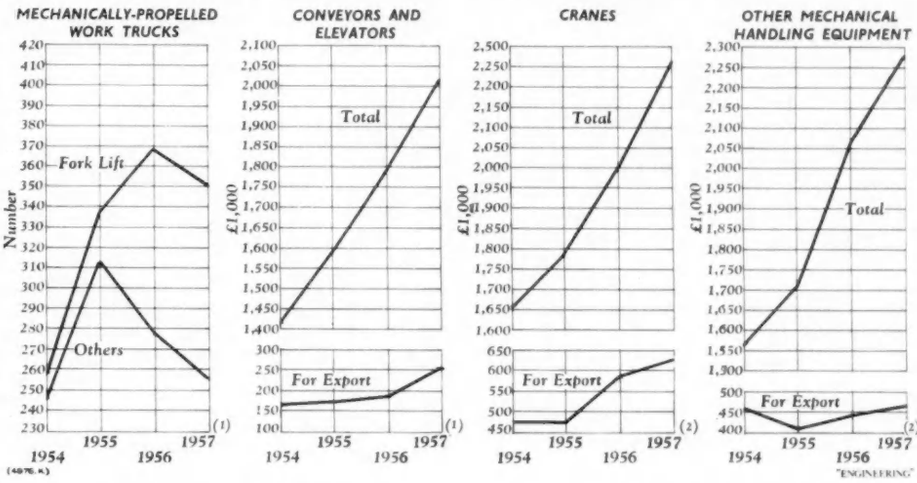
In general, as stated in the first article of this series, the outlook for many branches of the engineering industry in 1958 is very largely dependent on the trend of export demand. Even if it proves possible to reduce the level of Bank Rate in the spring, there is unlikely to be any marked increase in home demand before the late summer or autumn. In the United States opinion appears to have hardened in the last few weeks that the recession is likely to continue during the early part of 1958 though, so far as can be seen at present, it is not expected to intensify. An unwelcome New Year development has been the decision of the New Zealand Government to subject a wide range of imports to licensing. While the main effects of this measure are likely to be felt in the consumer goods field and particularly in textiles, footwear and clothing, New Zealand is an important market for British motor vehicles and a number of other products of the engineering industry.

A remarkable feature of the industrial scene in this country during the past year, however, has been the marked stability of overall industrial production in spite of the serious difficulties which have had to be overcome. These include the rationing of petrol following the Suez crisis, the raising of Bank Rate and the recession in the United States. While there has been a decline in orders received for capital goods such as machine tools, this has not yet been reflected in a fall in the level of output. Most sections of the engineering industry still have substantial, though in some cases declining, order books and it is still possible to hope that some relaxation of credit restrictions will become possible before a substantial decline in activity occurs.



(1) Estimated from first six months

Monthly average output of civil engineering and contracting plant (£1,000).



(1) Estimated from first nine months

(2) Estimated from first six months

Monthly average output of mechanical handling equipment in the United Kingdom.

WHAT THE INDUSTRIAL FILM CAN DO—FILMED

Recent articles and correspondence in ENGINEERING* give evidence of the interest there is in the possibilities of films for industrial purposes; but there are still many manufacturers and organisations who do not yet appreciate how the film can serve industry. Many regard it only as a "prestige" and sales-promotion accessory—indeed it can be an important one, and should be in every overseas salesman's kit—and perhaps as a training aid; whereas it should be seen as a means for introducing new ideas of all sorts—for recruiting future staff from the schools; for revealing to newcomers in an organisation its purpose and way of functioning, so that they can appreciate the part they have to play; and for explaining the reasons for changes in management organisation and workshop techniques before their introduction; and, of course, purely for documentary purposes—in the recording of some unusual process or piece of research.

To show the wide range of functions that the film can carry out, Film House Productions Limited, Film House, Wardour-street, London, W.1, have made a film "Presenting Film House Productions," for demonstration to the engineering and other industries, in which they outline their policy and show varied examples of this type of work being carried out, including the techniques at their disposal. Although the firm itself is a recent entrant to the industrial film production world, it has the advantage of sharing the technical resources, studios, and equipment of its associated companies, TV Advertisers Limited and TV Cartoons Limited; and its directors and executives have been drawn on the one hand from among documentary film technicians, directors and writers, and on the other hand, from men of commercial experience.

Film House Productions consider that it is their business not merely to make films to customers' specification, but to advise their clients on how to get the most out of their films; and, particularly in the case of prestige and sales-promotion films, how to plan them with a view to getting free distribution in the United Kingdom, either through government agencies or Gaumont British Instructional; and overseas through the Central Office of Information.

* "The Uses of Films" (page 619) and "Selling by Film" (page 622), November 15 issue; Letter to the Editor (page 676), November 29, issue.

GAS FOR SCOTLAND—RESOURCES AND DISTRIBUTION

The booklet *Gas for Scotland*, published last November by the Scottish Gas Board, contains a long-term review of changes in the Scottish gas industry. Over the whole country the gas industry has an important contribution to make in bridging the anticipated gap between domestic production of fuel and power and growing demands. Scotland possesses various resources ready to be tapped.

For example, the Scottish Gas Board have been the first in the country to make natural gas available for domestic supply. The natural gas is obtained from the well at Cousland from which a 4 in. diameter main has been laid to Musselburgh where the natural gas is mixed with coal gas from a continuous vertical retort installation and distributed to the town.

A further important development in hand is the complete gasification of small high-ash coal into gas at high pressure. Large deposits of suitable low grade coal are available at Westfield in Fife and plans are under consideration for the installation of complete gasification plant for the supply of 30 million cub. ft. of gas a day. The production of gas at high pressure would make possible the economic transmission of gas from large production units to centres of consumption at considerable distances.

As regards distribution, the Scottish Gas Board have planned two major integration schemes, the West of Scotland Grid, which will serve Glasgow, Renfrewshire and areas of Lanarkshire and Ayrshire, and the East of Scotland Grid, which will serve Fife, Kinross, Angus and part of Kincardineshire. During the twelve months to March last, over 140 miles of new mains were laid and 11 uneconomic manufacturing stations closed down.

Book Reviews

URANIUM THREADS AMONG THE GOLD

Uranium in South Africa, 1946-56. Volumes I and II. A Joint Symposium arranged by the *Associated Scientific and Technical Societies of South Africa, P.O. Box* 5907, *Johannesburg, South Africa.* (126*s.*)

Books on mining, concentration, and purification of uranium ore have been notable absentees from the large numbers of nuclear engineering works published. The only previous publication in this field has been the seventh volume of the proceedings of the 1955 International Conference on the Peaceful Uses of Atomic Energy held in Geneva. Although the present work deals only with a limited aspect of the subject, it does provide a detailed account both of the fundamental principles and engineering of the materials and processes.

All the uranium is derived from gold ore, and occurs as uraninite, a mineral consisting primarily of uranium dioxide (UO_2) and thucolite, a mixture of uraninite of various origins and hydro-carbon; it is also found in conglomerates and pyritic quartzites. The ore is first ground, after which the uranium may be brought into solution either before or after extraction of the gold.

The method of combined acid leach and oxidation has been chosen in preference to the alkaline leach performed elsewhere because manganese dioxide is readily available, and abundant iron pyrites has facilitated the development of a sulphuric acid industry. Leaching is carried out at between 50 and 60 deg. C. in " Pachuca tanks " (air agitated tanks with conical bottoms). The acid pulp is difficult to filter unless flocculated. Animal glue was the best available flocculant. Production of this had to be increased, and this led to difficulties of co-ordination of supply and demand, and storage problems had to be overcome. Uranium is removed from the sulphate solution by absorption on ion exchange columns using a resin based on cross-linked polystyrene the active group of which is a tertiary anime. Three beds are used. Uranium is eluted off with ammonium nitrate solution to form uranyl nitrate. Materials such as cobalt and thionates poison resins, and techniques of depoisoning have been developed. The pengrant solution for the ion-exchange process is then partially neutralised with lime which precipitates most of the remaining impurities which are then filtered off and the diuranate finally precipitated with ammonia or other alkalies. The diuranate slurry is shipped in tankers to the calcining works, settled, filtered on rotary vacuum filters, extruded to pellets, dried, and calcined on stainless steel trays or in a rotary calcining furnace, heated by calrod elements, to 98 per cent. of the pure oxide U_3O_8.

Besides dealing with the theoretical basis of the processes described the book deals at length with the origin and mineralogy of the uranium-bearing ores, describes the engineering aspects, supply and manufacture of materials, and plant (including stainless-steel casting manufacture), and includes methods of laboratory and process control and financial and political aspects. For a proper understanding a knowledge of chemistry or chemical engineering approximating to graduate standard is desirable. Anyone requiring a knowledge of the South African uranium industry as student, customer, prospective employee or supplier of equipment will derive benefit from a study of the book. It makes no attempt to be a general fundamental treatise on uranium extraction, but it should be of value to the mining engineer with sufficient knowledge of his subject to apply the methods of attack to his own problems.

Allowance must be made for the symposium presentation which viewed as a work of reference or information has defects. The book comprises a series of papers, most of which have received prior publication. The authors are clearly experts in their own particular field, but to obtain a balanced picture it is necessary to read both the particular paper, and the discussion. There is also some duplication, particularly as regards ion exchange processes carried out at different centres which, although similar, are described in detail more than once. If a suitable editor could be found, the book could be reduced to more manageable proportions and made a much more suitable work of reference. Room could then be found for comparison with processes used elsewhere. More discussions of possible future developments, such as the moving-resin process, and resin in pulp processes, would be advantageous. The only future development mentioned, is the economically very significant pressure-leaching process but an industry as healthy as the South African uranium industry must have many others under consideration.

CINDERELLA IN THE SAFE

Engineering Insurance. By R. H. PROCTER. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (30*s.*)

An engineering insurance register, if indeed such a book is kept at all, is usually the Cinderella of the modern factory, relegated to the depths of the company's safe, because the complicated phrasing, small print, and apparent absence of financial return of insurance policies, all militate against the coverage and facilities of insurance being widely known. Sometimes, a firm's secretariat is well versed in insurance matters but has no mechanical knowledge worth mentioning, at other times, there is an experienced plant engineer, or works manager, who knows nothing of the intricacies of insurance or, consequently, of the coverage he can obtain.

This book, probably the first of its kind on the subject, will help to close these gaps of knowledge, and will find its widest application beyond the student of insurance whom the author evidently intends to serve. It will help the student and administrator by its potted descriptions of an extensive range of plant, and it will help the mechanical engineer by its simple explanations of the coverage available for his equipment. The tone of the book is pleasantly avuncular, while, at the same time, maintaining strict legal accuracy. Non-insurance readers will have a distinct feeling of eavesdropping on private instructions to a youthful insurance agent, with accounts of the foolish and regrettable peccadillos of works managers the young man may have to deal with if he pursues his subject.

After a brief introduction to the history and growth of the compulsory inspection of plant, the author divides engineering insurance into four main categories: boilers, engines, electrical plant, and lifting appliances and cranes. Every alternate chapter, describing a particular item of plant with its application and the likely points of failure and accident, is followed by one in which the insurance implications are fully covered. Insurance proposal forms, schedules and policy forms are set out, and all the clauses and questions, with the reasons for them, are clearly explained. A helpful feature is the author's use of punctuation throughout the formal phrasing. This significant departure from established practice greatly aids the understanding of these clauses.

At the end of each of the categories of insurance, there is an excellent summary table which gives, for each plant item in the category: the scope of standard coverage; the additional coverage available; data on which the premium is based; and any special features. The difficult subject of insuring against loss of time due to plant breakdowns is rather thinly treated, but this is excusable in view of the difficulty in assessing the consequencies. Other shortcomings of the book are the absence of any basic premium figures or percentage rates to serve as examples, and of any of the statistical information regarding the frequency of accidents on which premiums are calculated.

At the end of the book are collected synopses of all the relevant Acts of Parliament relating to the compulsory inspection of plants, together with a comprehensive list of the appropriate forms supplied by H.M. Stationery Office. Elsewhere, there appears a list of the major engineering insurance companies, and mention is made of the non-insuring inspection services which they provide. Altogether, this is a readable and well-illustrated guide to the subject of engineering insurance, and one which reviews many important points that could usefully be known both before and after the buying of engineering plant.

COMBUSTION PHYSICS

The Spectroscopy of Flames. By A. G. GAYDON. *Chapman and Hall Limited,* 37 *Essex-street, London, W.C.*2. (50*s.*)

An earlier monograph on *Spectroscopy and Combustion Theory*, which was published in 1942 and revised in 1948, has now been replaced by the present volume. So much work has been published on the subject in recent years that the book has been almost completely rewritten, but it has inherited one character in particular from its predecessors, that of being very readable. If all spectroscopists wrote as simply and as clearly as Dr. Gaydon, the tasks of many scientists and engineers who are obliged to make occasional but not frequent excursions into the realm of spectroscopy would become considerably lightened. There we have one of the most compelling reasons for buying this book: it is an interpretation in familiar language of the work of specialists.

The emphasis of the work is squarely upon experiment. " Special Techniques," " Measurement of Effective Temperature," " Experimental Methods," these are some of the chapter headings, whilst other chapters on flames of various reactants are given an essentially descriptive treatment. Theory is far from neglected, but is described rather than developed. This is a wise choice in a book of this nature, and is quite deliberate. It enables the non-specialist to appreciate the character of spectroscopic observations without having first to comprehend fully the detailed mathematical treatment behind them. The lucidity of expression is to be praised, as for example, where the differences between the meanings of continuous and banded spectra are elaborated.

One chapter which is not predominantly concerned with experiment is entitled " Flame Structure and Reaction Processes." Here Dr. Gaydon " sticks his neck out," to use his own phrase, and with due warning enters the realm of opinion and speculation. No doubt there will be some who will disagree with various of the theories here advanced, but what can be more effective for stimulating further endeavour than a measure of disagreement. Indeed one suspects that the main purpose of this chapter is to promote further work on a number of topics on

which apparently contradictory observations are waiting to be reconciled. These topics include cool flames, pyrolysis and carbon formation in flames, and reactions forming excited radicals.

It is inevitable that a work will reflect the main interests of its author; and that is what makes this book such fascinating reading. One senses the personal enthusiasm throughout. It is in consequence also inevitable that some parts of the main subject implicit in the title will receive rather less emphasis than perhaps they merit. In particular the experimental techniques and scope of infra-red and mass spectrometric methods applied to flames have been given a treatment which is, if not scanty, somewhat inadequate in comparison with that meted to their ultra-violet and visible counterparts. One feels also that the limitations of spectroscopic techniques might have been stressed rather more.

But these are minor carpings on the part of a reviewer who can wholeheartedly recommend the purchase of this volume not only by those who are actively considering the application of spectroscopy to flames but also by all who are interested in the chemistry and physics of combustion processes.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Carburettors and Fuel Pumps, Gas Equipment and Special Assemblies. AMAL, LTD., Holdford-road, Witton, Birmingham, 6. The works of Amal, Ltd., are laid out to produce not only their well-known carburettors, fuel pumps and gas jets, burners and injectors, but also to manufacture to the trade a wide range of single parts or assemblies of comparable size. This illustrated brochure gives details of the works equipment and capacity, and of the items in normal production.

Switchboards. LANCASHIRE DYNAMO NEVLIN LTD. (SWITCHGEAR DIVISION), Hurst Green, Oxted, Surrey. Leaflet LS. 1800 deals with alternator control switchboards for industrial and marine installations. Leaflet LS.40 deals with the range of standard and " purpose design " heavy industrial switchboards with Unifront flush fronted switchboards for low tension distribution applications.

Cable Capacitance Monitor. ADDISON ELECTRIC COMPANY, LTD., 10/12 Bosworth-road, London, W.10. Capacitance monitor and controller system whose main application is the control of wall thickness of cellular or foamed plastics, of telephone and high-frequency cables whose specification calls for constant capacitance rather than constant diameter. Illustrated leaflet.

Ore Crushing. HADFIELDS LTD., East Hecla Works, Sheffield, 9. Crushing rolls for dealing with metal ores, macadam, ballast and ironstone, and for fine crushing of hard materials such as granite chippings, shale, limestone, cement clinker and quartz. Data are given for calculation of speeds and powers. Illustrated brochure.

Stacking Crates or Boxes. U.D. ENGINEERING COMPANY, LTD., Cumberland-avenue, Park Royal, London, N.W.10. Crates or boxes which are travelling on a conveyor, as in a brewery or a dairy, for example, can be built into stacks up to 7 high, at a maximum rate of 22 units per minute. Illustrated leaflet.

Portable Rectifier Welding. ENGLISH ELECTRIC COMPANY, LTD., Stafford. Portable rectifier welding equipment type LWD.350, fitted with infinitely variable current control between 25-350 amperes. The unit is suitable for 380/440 volt, 3 phase supply but units for other voltages can be supplied. Illustrated leaflet.

Instruments. ENGLISH ELECTRIC COMPANY, LTD., Stafford. Illustrated leaflets numbered MS/4014, MS/4015, MS/4016, and MS/4017 deal with the company's moving-iron switchboard instruments (round), rotary synchroscopes, moving iron switchboard instruments (square), and portable current density indicator. Illustrated.

Relays and Controls. LONDEX LTD., 207 Anerley-road, London, S.E.20. Data book marking 21st birthday of the firm. Contains information concerning firm and its products, which include a variety of relays, counters, timers, photo-electric devices, and fluid and gas controls. Illustrated booklet.

Gate End Box. BELMOS COMPANY, LTD., Bellshill, Lanarkshire. Description and photograph of new gate end box designed to comply with N.C.B. specification. Unit rated at 150 amperes and for use on a.c. systems up to 650 volts.

Welding Transformers. ENGLISH ELECTRIC COMPANY, LTD., Stafford. Range of multi-operator welding transformers with inbuilt power-factor correction capacitors and fuse-switch units. Illustrated leaflet.

Copying Lathes. WICKMAN LTD., Coventry. Technical bulletin dealing with the advantages of constant cutting speed and feed as obtainable on the Swiss Dubied copying lathe.

Welding Equipment. ENGLISH ELECTRIC COMPANY, LTD., Stafford. Three-phase multi-operator welding equipment suitable for shipyards and large workshops. Illustrated brochure.

On the Shelf

By Frank H. Smith

Lest any of my readers think my musings are out of date before they see the light of day, it gives me pleasure to announce that yesterday (the 23rd) the house of Blackie published a most important book. I refer to *Hydro-Electric Engineering Practice*, in three volumes. The general editor of this large work is Mr. J. Guthrie Brown, M.I.C.E., of Sir Alexander Gibb and Partners, consulting engineers. A number of contributors—25 to be exact—helped to compile the volumes of which No. I is concerned with civil engineering, II, mechanical and electrical engineering and III, economics of operation and maintenance. At 19 guineas this sounds a somewhat expensive proposition but Blackie's previous two-volume work on the subject (Gibson, Professor A. H.) was published in 1921-22, and both hydro-electric engineering and the cost of text-books have advanced considerably in 25 years. The publishers claim that the work is the most extensive and detailed so far produced despite the vast American tomes that are to be had; this could be true. A full review of this important work will appear in next week's ENGINEERING but it was felt that readers should have the earliest notice of this technical publishing event.

A headline in the American Society of Mechanical Engineers' monthly, *Mechanical Engineering*, for December, caught my eye—" Bad Technical Writing "—since it is a subject in which I am interested in an amateur sort of way. John L. Kent, of the Technical Writing Improvements Society (TWIS), Pasadena, California, has discovered a heap of bad writing, and TWIS aims to " make science and industry understandable." The ultimate solution is a better grounding in schools and an insistence on better style in advanced courses but, meanwhile, such partial solutions as sending technicians to short-story writing courses are being tried. In view of the subject of the paragraph I was intrigued to see a reference to " beefing up " courses, such as those held annually by the Technical Writers Institute of the Rensselaer Polytechnic Institute, Troy, N.Y. " Beefing up " is, of course, just the thing for bad writers. *Mechanical Engineering* refers also to a *Glossary of Terms in Nuclear Science and Technology* announced jointly by the American Standards Association and the American Society of Mechanical Engineers. It is American Standard N.11-1957 and may be obtained from the A.S.M.E., at 29 West 39th-street, New York 18, U.S.A., at 5 dols. per copy. The book, incidentally, is the result of 21 technical societies combining their glossaries to produce one all-embracing co-operative effort.

From time to time one sees jokes in which the theme is a man trying to carry on a conversation with the aid of a phrase-book in a foreign tongue. It is, of course, practically impossible to get along in a strange land with such expressions as " Where can I buy flowers for my wife (girl friend)?" but there is no doubt that when it comes to technical translation, specialised glossaries and phrase-books can be a great help. A single word can mean something quite different when it is applied to technology or appears in a special context. As for those compounds of which the Germans are so fond, one word can start with a capital letter and finish with a full stop; almost, anyway. Which brings me to one of the latest glossaries on a specialised subject. Cleaver-Hume Press Limited, 31 Wright's-lane, London, W.8, have published *Conference Terminology*—a manual for conference members and interpreters in English, French, Spanish, Russian, Italian and German. It is a slim volume (147 pages) for 12*s.* 6*d.*, but one must take into account the work that has gone into it. There are 756 phrases and expressions and the six-language index uses the phrase-number as an indicator. The dictionary has six divisions (A. Types of meetings, B. Preparation of the meeting, etc., etc.), and the divisions are subdivided again. " Documents," for instance, is divided into basic documents, agenda resolutions, programmes, and so forth. My eye was caught by maintenance of order under " debates " with such choice phrases as " To expel from the hall," " To cause a disturbance," " To call to order," and so on. Very useful to know these in six languages. The general editor of the book is Jean Herbert, former chief interpreter of the United Nations.

At the end of last year I was chided (one of these British understatements) for not numbering the pages of my material before sending it in. After I had abased myself and done the requisite penances I was told that I was not alone by a long chalk. It seems that quite a number of writers and scribblers forget to do this and when one comes to ponder on the matter it really is a singularly foolish omission.

I have been asked whether there is any special agency for keeping the *Oxford Dictionary* primed on new words. I do not know the answer to this but when, in the course of searching literature I come across a new word, or an application of an old word, I drop a line to the Secretary to the Delegates, Clarendon Press, Walton-street, Oxford, giving the reference and context. A case in point is " plasma " which seems to have undergone a change from the meaning given hitherto. Any of us who take an interest in our own language should make sure that it continues to live and those who think that " propellant " or " propellent " does not matter two hoots may be right but they miss a lot of fun.

The British Standards Institution *News* for November has a happy little paragraph headed " *Flam*mability is the word " the context of which is that they are all in favour of non-confusion. Why, they say, should it be *in*flammability. Bring on cessant, delible, superable and the rest of them. Remove ambiguity they urge. They then announce the new British Standards, one of which covers " absorbency test for *bibulous* paper " and the other " anaesthetic airways "! The first should rouse the temperance enthusiasts and the second might bring a protest from British European and Overseas Airways Corporations.

The Russians would appear to be having a drive to produce dictionaries of eastern languages. They even have a " Publishing House of Foreign and National Dictionaries." Arabic, Kurdish, Chinese, Japanese, Bengali, Hindi, Viet-Namese, Indonesian, Burmese, Urdu, Punjabi and Tamil are among the dictionaries already available or contemplated.

Design

THE WIGNER EFFECT

By P. J. Grant, M.A., PH.D.

Atomic Energy Division, General Electric Company, Limited, Erith, Kent

The accident at Windscale, which occurred during a controlled release of Wigner energy, dramatically drew public attention to the phenomena known to nuclear engineers as Wigner effect. When the Windscale piles were designed, little was known of the changes that took place in graphite moderators as a result of irradiation, but in the reactors now being built for the electricity boards, full allowance is made for such changes. The following article has been prepared by Dr. P. J. Grant, of the Atomic Energy Division, General Electric Company, who with the Simon Carves group are responsible for the design and construction of the nuclear power station to be built at Hunterston in Scotland.

Factors in the Design of Graphite Moderators for Nuclear Reactors

The neutrons which come from nuclear fission are " born " with high energy. In a thermal-neutron nuclear reactor it is necessary to slow down these fast neutrons so that they can cause further fissions, and it is for this purpose that the moderator is present. A moderator is a material (preferably with a very low probability of capturing neutrons) consisting mainly of atoms of low atomic weight so that the neutrons lose energy by elastic (billiard-ball) collisions. Virtually all of the neutron energy is dissipated in the moderator in this way.

It was pointed out by E. P. Wigner that in the case where graphite is used as the moderating material there existed the possibility that, instead of appearing as heat, some of this energy could be stored in the crystal structure of the graphite and that even if only a small fraction of the energy were " locked up " in this way a potentially serious hazard could exist if it were to be suddenly released. The Wigner effect, as it is usually called, is only a particular case of damage to materials by nuclear radiation but it is one which has to be seriously considered in the design of all graphite-moderated nuclear reactors in order to ensure that under all conditions the reactor shall remain safe.

Properties of Graphite

The graphite crystal consists predominantly of carbon atoms arranged in planes, the atoms being linked in a hexagonal lattice in each plane. The physical properties of the graphite crystal are anisotropic, those in the direction at right angles to the crystal planes being different from the properties measured parallel to the crystal planes.

Graphite in bulk is made artificially by grinding up very pure coke, mixing with pitch and then baking. This baking is usually carried out in two stages; first a preliminary stage at about 1,000 deg. C. to remove volatile components, and then a final treatment at a temperature of between 2,500 deg. C. and 3,000 deg. C. in a special graphitising furnace.

Before baking, the required shape is made from the plastic mixture of coke and pitch either by extrusion or by pressing. During this forming process an alignment of the atoms is caused so that the final graphite (which is not one crystal but a polycrystalline mass) tends to have its crystals oriented with their planes parallel to the direction of extrusion in extruded graphite, or perpendicular to the direction of applied pressure in pressure-moulded specimens. The degree of orientation of the graphite crystals depends on the original coke particles and on the pressure used in the forming process so that the physical properties of different graphite specimens vary with the process of manufacture. This applies both to the anisotropy of the properties (dependent on the orientation of the crystals) and their magnitude.

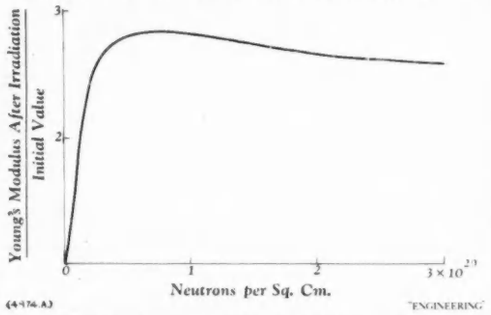


Fig. 1 Variation in the Young's Modulus of graphite when irradiation is carried out at low temperatures. Irradiation increases the hardness and mechanical strength of graphite, which also becomes more brittle.

Effects of Irradiation on Physical Properties

Under irradiation the collisions of neutrons with carbon atoms in the crystals of the graphite cause these atoms to be knocked out of their positions in the crystal lattice. The displaced atoms are themselves moving fast so that they in turn may eject other carbon atoms. The result is the production of vacancies in the lattice together with atoms or groups of atoms in positions between the lattice planes (interstitial atoms). The macroscopic effects of neutron irradiation are due to these processes. Raising the temperature of the graphite after irradiation will anneal much of the radiation damage; the amount of damage is strongly dependent also on the temperature of the graphite at which the irradiation is carried out; in other words, a self-annealing process occurs. Both of these effects can be readily understood in terms of a " loosening " of the structure at higher temperatures when the carbon atoms are vibrating due to their thermal energy. This " loosening " makes it easier for interstitial atoms to migrate into vacant lattice positions and restore the ordered array. The changes which occur under neutron bombardment are as follows.

(1) *Changes in Mechanical Properties.*—Irradiation increases the hardness and mechanical strength of graphite but it becomes at the same time more brittle. When irradiation is carried out at low temperatures (approximately room temperatures) increases in Young's Modulus of factors of 2 or 3 are observed.[1, 2] The form of this variation is shown in Fig. 1.

(2) *Changes in Thermal Conductivity.*—Irradiation produces large changes in thermal conductivity, these changes occurring rapidly with a short irradiation and then more slowly as the irradiation is prolonged. The change is a decrease in conductivity; it differs slightly in the directions parallel and perpendicular to the extrusion direction but is in the region of a factor of 50 for an irradiation of 10^{21} neutrons per sq. cm. at room temperature. This radiation exposure corresponds roughly to two years in one of the nuclear power stations at present under construction; however, the temperatures in these reactors are high (~ 300 deg. C.) so that irradiation effects will be much smaller than the figure quoted.

(3) *Changes in Electrical Properties.*—Changes in electrical properties are not in themselves important in reactor construction but since electrical measurements can be made with great accuracy they provide a very useful means of observing the progress of radiation damage in graphite specimens. The magnitude of the electrical changes is considerably smaller than the thermal conductivity effects.

(4) *Dimensional Changes.*—The presence of interstitial atoms and vacancies in the crystal lattice causes an increase in the spacing between crystal planes and a contraction parallel to the planes. In an individual crystal these effects can be quite large; in a bulk specimen of graphite, which consists of an aggregate of crystals, the effect is qualitatively the same owing to the partial alignment of the crystal planes. Quantitatively, however, the effect is much smaller since the crystals are not completely aligned and also the bulk material contains voids (the density of the graphite crystal is 2·25 gm. per c.c.,

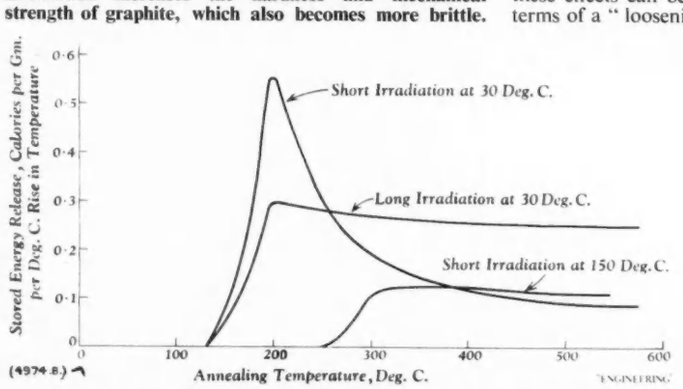


Fig. 2 Release of energy stored in graphite during irradiation. The extent of the release varies with the annealing temperature employed.

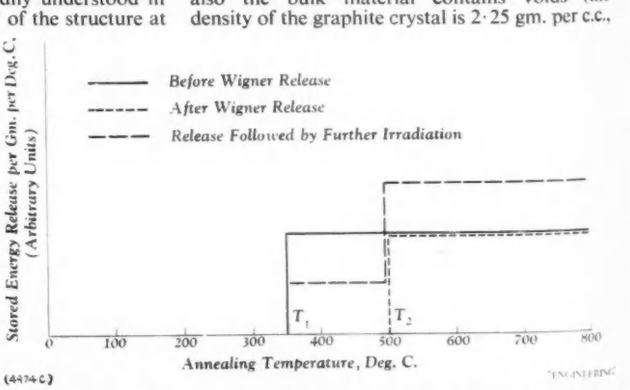


Fig. 3 Wigner energy release. Not all the energy can be released since this would involve raising the overall temperature to about 1,500 deg. C.

while the bulk material has a density in the region of 1·6 to 1·8 gm. per c.c.). The bulk material grows perpendicular to the direction of extrusion (or parallel to the direction of applied pressure in pressed specimens) and in the other direction the effect is small and may be either a shrinkage or an expansion.

A graphite moderating core for a reactor consists of graphite bricks stacked above each other with their direction of extrusion vertical, Wigner gaps being left between the graphite columns to allow for the lateral expansion under irradiation. (See ENGINEERING, November 15, 1957, page 637.)

(5) *Stored Energy.*—The damage to the crystal lattice is accompanied by a storage of energy in the graphite. If the temperature of the graphite is subsequently raised the damage is partly annealed and at the same time stored energy is released.

Typical figures for the energy storage at various irradiations (irradiation temperature 30 deg. C.) are as shown in the table below.

Irradiation (neutrons per sq. cm.)	$0{\cdot}5 \times 10^{21}$	$1{\cdot}0 \times 10^{21}$	$1{\cdot}5 \times 10^{21}$
Energy (calories per gm.)	250	400	500

These figures are to be compared with the specific heat of graphite which is from 0·2 to 0·4 cals. per gm. per deg. C., varying with temperature. For example, after an irradiation of 10^{21} neutrons per sq. cm. there is potentially enough energy stored in the graphite to raise its temperature by about 1,000 deg. C. should this energy be released. Of even greater interest, therefore, than the total stored energy is the manner in which this energy is released.

If the energy has been stored at a temperature T_0 and the graphite temperature is steadily raised little or no heat is released until a temperature T_1 is reached, which is roughly 100 deg. C. above T_0. Above this temperature the rate of release is more or less constant up to a temperature of about 1,500 deg. C. This behaviour applies to specimens which have had a prolonged exposure to radiation. For short exposures at low temperatures (as in the figures quoted above) the pattern of energy release is slightly different: the starting temperature T_1 is still about 100 deg. C. above the exposure temperature but there is a peak in the energy release rate in the region of 200 to 300 deg. C. Fig. 2 shows typical curves of rate of release of energy versus temperature for two irradiations at about 30 deg. C. and a typical curve when the energy has been stored at a higher temperature (about 150 deg. C.). In this latter case the quantity of energy stored (and the changes in most physical properties) during a given irradiation is reduced by a factor of the order of 10 as compared with the same irradiation at 30 deg. C. Higher irradiation temperatures lead to even greater reduction in the energy storage.

(6) *Annealing.*—It has been already seen that the stored energy can be partially released from irradiated graphite by thermal annealing at a higher temperature. The other changes in physical properties are also annealed at the same time.

In considering a practical case, the stored energy in the graphite of a reactor is the effect which is of the greatest importance. For any reactor design it is necessary to compute: (1) the energy storage in the graphite at all points in the reactor as a function of time; and (2) the corresponding rate of release of energy if the graphite temperature should be raised.

To compute the total stored energy it is necessary to know the neutron flux at the point considered, the temperature of the graphite at that point and the way in which energy is stored by irradiation at that temperature. It is thus necessary to have a wide background of experimental information if accurate predictions are to be made.

To calculate the rate of energy release the simplifying assumption may be made that the rate is constant over the range T_1 to 1,500 deg. C. where T_1 is the temperature at which energy release begins. (This is a pessimistic assumption because of the peak at temperature around 1,500 deg. C. and does not, of course, apply to short irradiations at low temperatures, but these are of no practical interest in power reactors.) If the total stored energy at an irradiation temperature T_0 is S, then the release of energy per unit rise of temperature (deg. C.) is

$$\frac{dS}{dT} = \frac{S}{1500 - T_1} = \frac{S}{1500 - (T_0 + 100)} = \frac{S}{1400 - T_0}$$

A hazard from the stored energy only exists if

$$\frac{dS}{dT} > \text{specific heat of graphite.}$$

In such a condition, if there were no heat losses and no cooling were applied, the stored energy would all be released if the graphite temperature for any reason exceeded T_1. This point is therefore taken as the criterion for assessing the hazard due to stored energy even though in a practical case this limit could be safely exceeded, since under the conditions when a spontaneous release is likely there is always some flow of coolant gas.

The procedure is thus to calculate the energy storage in the different parts of the reactor and decide which is the worst position. Graphite samples are distributed throughout the reactor, the number being increased in the region predicted to have the worst conditions, and at intervals these are taken out and examined and the stored energy measured for comparison with predictions. When one of these samples approaches the allowed limit (which contains a substantial margin of safety over the hazardous condition) an annealing process is carried out.

In the annealing process the temperature of the graphite is slowly raised by applying heat from an external supply and some of the stored energy is released. Not all the energy can be released since this would involve raising the temperature of all the graphite in the reactor core to about 1,500 deg. C.; if the annealing temperature is T_2 a fraction of the energy $\frac{T_2 - T_1}{1500 - T_1}$ is released (Fig. 3). What this means is that the threshold for energy release is raised by the annealing process from T_1 to T_2. Thus by making T_2 sufficiently high it is possible to ensure that spontaneous energy release cannot occur even if there should be a local temperature transient during reactor operation. Owing to the great thermal inertia of the moderator large temperature transients in the graphite cannot occur, but any process which increases the safety margin is obviously desirable.

REFERENCES

[1] W. K. Woods, L. P. Bupp and J. F. Fletcher, *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva*, paper 746.

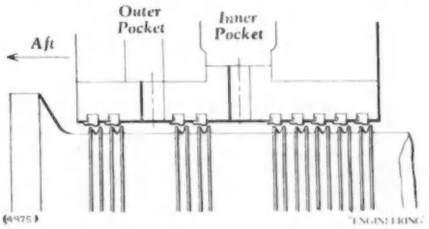
[2] G. M. Kinchin, *Ibid*, paper 442.

HEAT DISTORTION EFFECTS IN IMPULSE STEAM TURBINES

Relative movements of the parts of a steam turbine, due to thermal effects, present a number of design problems which cannot always be anticipated at the initial design stage. Modifications become necessary in the light of experience and future designs gain from this operational development. Some of these problems and the methods used to overcome them were outlined by Mr. E. L. Denny in the Thirtieth Thomas Lowe Gray Lecture, on " Machinery for Cross-channel Passenger Ships," given at the Institution of Mechanical Engineers on Friday, January 17.

The turbine under discussion is the Pametrada single-cylinder impulse turbine which has a number of advantages where a low usage factor makes first cost of installation of greater importance than fuel economy, and where machinery must be easily handled and brought rapidly to full power. It has a relatively low first cost, ease of inspection, maintenance and operation, and rapid warming through and shut down.

The turbine has an outer casing of welded



Spring-backed sealing glands allow for casing distortion.

steel construction. Exhaust steam enters the space between the inner and outer casings. In the early designs it was supposed that, since the outer casing was at a temperature corresponding to the saturation temperature of the exhaust steam, there would be little trouble with casing distortion. However, dimensional changes were found, in practice, to occur in the outer casing which were attributed to thermal leakages and higher exhaust temperatures, in some conditions of operation. These distortions were sufficient to cause damage to one installation and to stimulate some experimentation to overcome the trouble. Trials were made to investigate the advantages of a sliding foot at one end of the turbine. This had the effect of reducing the maximum measured vertical deflections of the casing from 0·022 in. for the fixed feet to 0·008 in. for sliding feet.

In designs made subsequently to these trials, sliding feet were used, but by coincidence the deflection already quoted, of 0·022 in. in the outer casing relative to the rotor bearings, occurred once again: this time due to a modification of the inlet steam piping. The difficulty was overcome by a combination of measures. Saw cuts were made vertically in the outer casing to reduce the heat leakage to the bearing pedestals. Special precautions were taken to shield the outer casing from possible high-temperature steam leakage. The main solution was to increase gland clearances and fit spring-backed glands.

These glands, shown in the accompanying illustration, are now an established feature of the Pametrada turbine and reduce the risk of bent rotors as a result of casing distortion. Smaller gland clearances can be used in a given turbine. The Pametrada design consists of a number of segments held radially inward against coil springs which have clearance for expansion. Rotation is prevented by stops at the horizontal joints.

Radial expansion between the inner and outer turbine casing is allowed for by using a flexible diaphragm which closes the annulus between the forward inlet branch and the outer casing. This avoids the use of glands which would be detrimental to a good vacuum.

Two design features which have been likely causes of thermal distortion are nozzle boxes cast integrally with the main barrel, and bearing pedestals supported below the horizontal centre line. The first of these has now been improved by using cast nozzle boxes bolted to the main inner barrel. Flexibility has been designed into the nozzle box to reduce the thermal effects on the main barrel. The bearing pedestal is now supported at the horizontal centre line and this arrangement avoids the differential expansion between the bearing casing and the outer pedestal.

Continuing **Design**

STABILISING SMALL SHIPS

Although activated-fin stabilisation of large ships is now an accepted feature of shipbuilding practice, it has not generally been adopted on small ships below 1,000 tons displacement, due to the difficulty of installing the equipment in the restricted space available. For some considerable time, however, Saunders-Roe (Anglesey) Limited have been co-operating with William Denny Brothers, Limited, Dumbarton, and Brown Brothers and Company, Limited, Edinburgh, in developing a range of units readily adaptable to a wide variety of small ships and boats. In this development, Muirhead of Beckenham, Kent, have co-operated in the design of the gyroscopic control unit.

The Saunders-Roe design uses the Denny-Brown activated-fin principle and also the feature of direct retractability. Both of these features have been well proven over the past 25 years. The novelty of the new design lies in its structural and mechanical details which, it is claimed, give it a simplicity, compactness and ready facility for production on a standardised basis. The system consists of: (1) port and starboard mechanical units which include fins, finboxes and operative mechanism; (2) either a self-contained electrically-driven hydraulic power pump, or an engine-driven hydraulic power pump; (3) a sensitive hydraulic supply and control system working on the constant-pressure principle; and (4) a gyroscopic unit which forms the basis of the sensory control of fin movements.

to the hull structure. It also ensures complete freedom from vibration due to finshaft journal loads. The fin is actuated by coupling a double-acting hydraulic ram to the lever *l*.

As in all Denny-Brown designs, the fin is in two portions, a mainfin and tailfin. The mainfin is oscillated through a total of 40 deg. while the tailfin automatically travels through a total of 100 deg. actuated by a simple shackle device attached to the crosshead *x*.

The units are substantially constructed to give long life with the minimum of maintenance, suitable protection against corrosion being provided where necessary. The fins are fabricated from steel forgings and plate. The drive shaft is in 3 per cent. chromium molybdenum steel, nickel-plated by the Fescol process. The fin-bosses are made from mild steel plate and are provided with flanges for attachment to ship. All bushes in contact with water are of Ferrobestos and provision is also made for their lubrication by grease-gun application of Neox underwater lubricant. The sea gland on each unit is of substantial proportions, thus ensuring freedom from seepage of seawater.

Hydraulic power is supplied by a self-contained electric motor directly coupled to a Lockheed hydraulic pump, working on the ship's supply, either alternating or direct current and giving hydraulic pressures in the region of 1,500 to 2,000 lb. per sq. in. A large-capacity hydraulic supply tank is fitted immediately above the

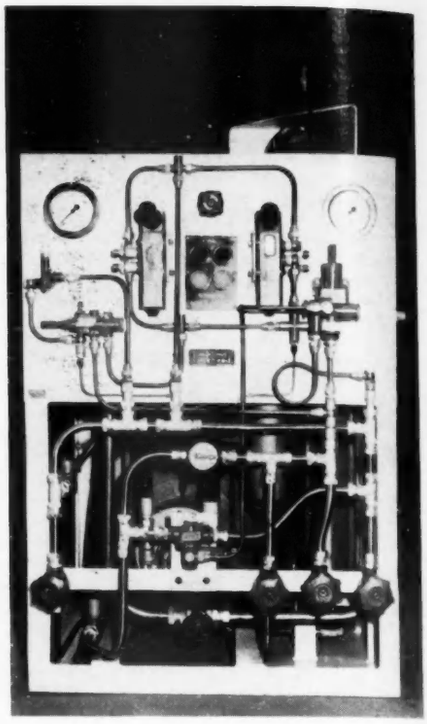


Fig. 2 The control panel for the stabilisers, normally fitted in the engine room.

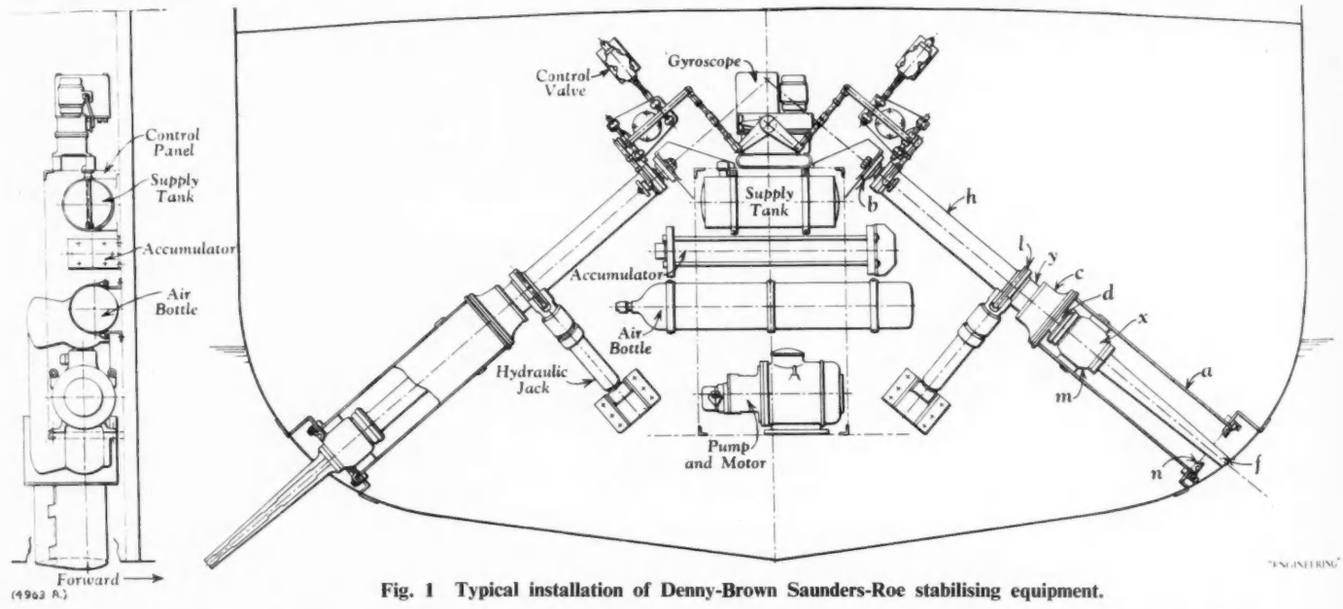


Fig. 1 Typical installation of Denny-Brown Saunders-Roe stabilising equipment.

Referring to Fig. 1, a watertight finbox *a* is rigidly integrated with the hull structure and fitted with an end cover *c* which carries a conventional sea gland. From a bearing *b*, disposed near the centre of the ship, a two-piece sleeve *h* and *y* is trunnioned. The portion *h* serves as a hydraulic jack for extending and retracting the fin, and the portion *y* takes the drive from the lever *l* to the finshaft. The top and bottom plates of the finbox are machined to form guides for a crosshead *x* which is free to slide endwise but is restrained from rotation about the finshaft.

The finshaft is in two portions, the fin *f* proper and the driving part *d*. A piston on the inner end of *d* slides within the cylinder *h* and a journal on *f* is housed in the crosshead *x*.

The tapered face on the crosshead mates with the bracket *n* fixed to the outer end of the finbox. This serves as an outer lock when the fin is extended, being held in contact by hydraulic thrust and thus transferring all loads directly

motor, from which fluid feeds by gravity to the suction side of the pump through a Purolator Micronic filter. A hand-operated starter box and switch box is mounted on the control panel.

As an alternative arrangement, the hydraulic pump may be driven from a main propelling engine if a suitable power take-off is available on the engine.

The functions of the hydraulic system are: (i) to extend and retract the fins into and from the water, and (ii) to actuate the fins in answer to the gyroscope signal with the minimum of time lag. Constant pressure is sustained in the circuit by a large-capacity air-loaded hydraulic accumulator.

The extension and retraction of the fins is controlled by means of manually-operated control valves on the control panel (Fig. 2). Hydroloc valves provide a positive hydraulic lock in either the inboard or outboard positions. Signal lights on the control panel indicate whether the fins are housed or are projecting into the water. The fins cannot be actuated until they are in their proper working position.

The Muirhead gyroscope unit, a simplified version of that used on large ships, provides a means of measuring the rolling velocity of the vessel and, through the use of a Servodyne mechanism, gives a signal of sufficient strength to control the hydraulic circuit. Power to operate is taken from the ship's electrical system.

The pump and motor drive are controlled from a panel in the engine room, as is also the extension and retraction of the fins. A push-button control is provided for fitting on the bridge so that the commander may operate the fins at his discretion; and, if desired, complete control of all operations from the bridge can be supplied.

The Denny-Brown Saunders-Roe stabiliser has aroused considerable interest both at home and abroad. The British Admiralty is having an inshore minesweeper fitted with the gear, and other navies are studying its obvious advantage.

POWER DIVIDING TRANSMISSIONS

By D. L. Bedingfield, LL.B.

The type of transmission considered is that in which the input power is divided between two or more channels, one of which has a continuously-variable speed characteristic. The object of this type of drive is to retain the continuously-variable ratio, but to reduce the amount of the losses commonly encountered in such mechanisms by reducing the amount of power it is called upon to transmit. Epicyclic gearing is an example: here the turns ratio of the input element to the output element when the reaction element is stationary is r. In a two-path transmission, the variable drive is coupled between the reaction element (which is otherwise free to rotate) and either the input shaft (torque-dividing system) or the load-shaft (speed-dividing system). The first feeds $\left(\frac{sr-1}{sr}\right)$ of the input power through the variable drive, and the latter $(1 - sr)$, where s is the overall speed ratio.

Geared three-path transmissions, such as that shown in Fig. 1, require two gear trains. The variable drive is coupled between the two reaction elements, and the input shaft drives one element of each train. The remaining element of the first train (ratio r_1) is coupled directly to the reaction element of the second (ratio r_2), and the remaining element of the second train drives the load. Ideally, the proportion of input power traversing the variable drive is

$$\frac{sr_2 - 1}{sr_2} \times \left[1 - \frac{r_1 r_2 \left(s - \frac{1}{r_2}\right)}{r_2 - 1}\right].$$

Fig. 2 shows a typical power division for the system shown in Fig. 1. The sun and planet wheels in the gear trains are identical so r_1 with the annular gear wheel driving is $1\frac{1}{3}$, and r_2 with the sun wheel driving is 4. Curve A is the torque dividing characteristic $\left(\text{equals } \frac{sr_2 - 1}{sr_2}\right)$; B is the separate speed dividing characteristic (equals $1 - sr_1$) for power not directed directly through the second gear train; C is B realigned to take account of overall speed ratios; and the hyperbola D combines A and C to show the proportion of input power traversing the variable drive. Operation below the zero-power axis is regenerative.

Fig. 3 compares maximum and minimum speed ratios of different systems for given ideal peak proportions of input power traversing the variable drive. A is a two-path system with regeneration; B a three-path system without regeneration; and C and D the same with different amounts of regeneration.

A model was constructed using the inherent power dividing characteristic of one of a pair of electrical machines to provide a three-path transmission with one differential train. A practical example of a power dividing transmission occurs in the compound "Nomad" engine.

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 36 *Bedford-street, Strand, London, W.C.2. Price 25s. each, post free.*

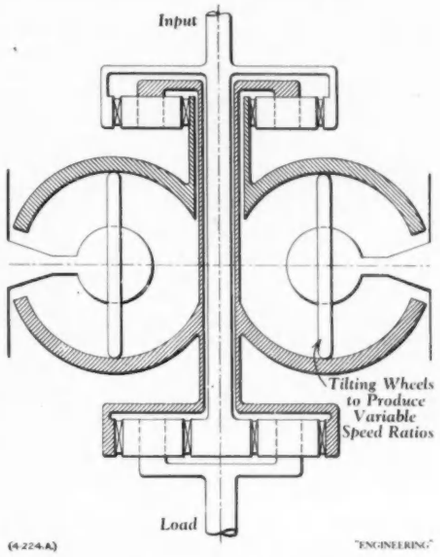


Fig. 1 One purpose of a power dividing transmission is to enable a continuously-variable speed mechanism to be used with reduced transmission losses. A three-path example is shown here.

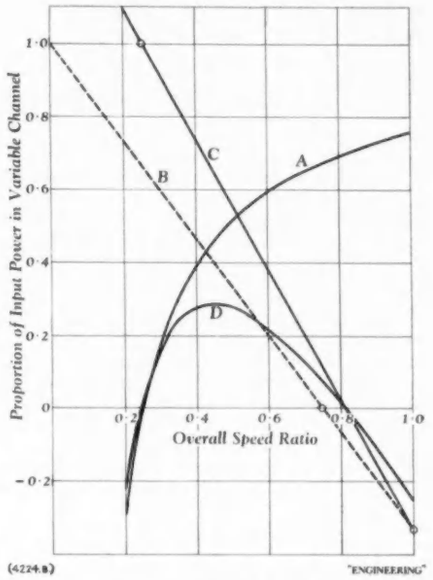


Fig. 2 Curve D, developed from the power and speed dividing characteristics A and B, shows the proportion of power traversing the variable channel of the system in Fig. 1.

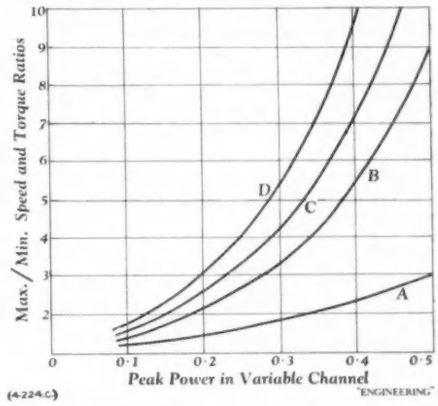


Fig. 3 Peak proportion of input power traversing the variable drive for different systems.

FLYWHEEL LOCOMOTIVE

For some little while, an experimental bus has been running in Switzerland, which utilises the stored energy of a flywheel to move it from point to point. At these points the energy can be restored by speeding up the flywheel by a motor which obtains its power by plugging into a mains supply. Now the National Coal Board have developed a locomotive for surface shunting which operates on much the same principle, the energy being stored in two flywheels each of which is combined with a squirrel-cage induction motor. Electrical energy is drawn from a 3-phase supply and converted to kinetic energy in the flywheels, then, when the locomotive moves, kinetic energy is converted back into electricity and feeds the two traction motors which drive the locomotive. The speed range of the flywheels is from just under 3,000 r.p.m. to about 1,800 r.p.m. One "charge" taking $2\frac{1}{2}$ minutes is sufficient to give the locomotive power for working for about 30 minutes. A short run followed by a stop is the type of duty which corresponds closely to the operating cycle of this locomotive and such duty would be suitable for hauling underground trains. The electrical equipment was produced by Oerlikon and the mechanical parts by Sentinels (Shrewsbury) Limited.

For the present trials, three charging stations are employed: one in the engine shed, and two on the line, about a mile apart. When the locomotive stops at a charging mast, a collector pole is swung out pneumatically, connecting the locomotive with four bare contact rails which are not alive until a pilot circuit through the locomotive closes the contactor in the charging station. The flywheels are then run up to near synchronous speed, at which 18 kWh of energy are stored, of which about 12 kWh can be used. The remainder represents the energy stored at the minimum working speed of the flywheels.

When the charging mast is swung back, the locomotive can move. The electrical principle underlying operation is that a 3-phase induction motor will generate alternating current when driven externally and excited by condensers. Two banks of condensers are housed in the front compartment of the locomotive. The driver operates a handwheel to regulate the value of capacity connected, which together with the load on the traction motor (weight of train, gradient, locomotive speed) and the flywheel speed determines the voltage generated by the rotors. There is an automatic voltage limiting device compensated for starting currents.

A second manually-operated controller changes the connections of the traction motor windings and gives the locomotive four forward and four reverse speeds. This is achieved by altering the number of poles and the result may be likened to a gearbox. With fully charged flywheels there are these relationships for the four controller positions: motor connections (poles), 12, 8, 6, 4 corresponding to maximum locomotive speeds of 4, 6, 8, and 12 m.p.h.

The flywheels run in an atmosphere of hydrogen at reduced pressure. This system of cooling electrical machines and reducing windage losses has been used on large turbo-alternators in power stations, but probably not for small machines of the size of the Electrogyros. As a result it takes about 11 hours for a rotor to come to rest from maximum speed; air at normal atmospheric pressure would stop the flywheel in 4 hours. The hydrogen also reduces the loss of flywheel r.p.m. at signal stops and traffic hold-ups. With the locomotive standing, the flywheels take over $1\frac{1}{2}$ hours to slow down from their maximum speed to 1,800 r.p.m. It takes considerably longer for the rotor speed to fall to a value at which the locomotive is immobile.

Where flywheel locomotives are used, the number and position of the charging stations are based on a careful assessment of the duties. The $2\frac{1}{2}$ minutes required by a charge are not necessarily detrimental, as traffic conditions make stops inevitable. Where it is desirable to have the locomotive instantly ready for duty at the beginning of a shift, the flywheels need never run down; a reduced charge in the shed can maintain the speed as required. The original application of the Electrogyro (to a railcar) was described in ENGINEERING, vol. 163, page 540 (1947).

Continuing **Design**

HIGH SPEEDS ON SHARP CURVES

Swinging Coach Increases Comfort

Super-elevation has never been a satisfactory solution to the problem of negotiating railway curves at speed. Experiments carried out by the French Railways suggest that the discomfort of centrifugal acceleration can be overcome by the use of a "pendulum" suspension. Such an arrangement is not likely to eliminate the need for super-elevation of the rails but the coach body will take-up the inclination corresponding to its speed around the curve.

When a vehicle travels at speed round a curve, it tends to be pushed outwards by the centrifugal force. In theory, this action could be compensated by adequate super-elevation of the track, but in practice such a remedy is strictly limited in its effectiveness. It has to be borne in mind that some goods trains run slowly, and that some trains may have to be brought to a stop on a curve. An accentuated super-elevation would then have the disadvantage of placing an inordinate strain on the inner rail. In actual fact, up to 6 in. of super-elevation is permissible on fast lines, which corresponds to about $0{\cdot}10g$ of uncompensated acceleration. This is a maximum. For example, on the Paris-Lyons line, for a speed of 87 m.p.h. on a curve with a radius of 3,116 ft., 5·5 in. of super-elevation is permitted, corresponding to about $0{\cdot}07g$ of uncompensated acceleration.

Experiments carried out by the French Railways in 1947 proved that lateral acceleration by centrifugal force in excess of $0{\cdot}10g$ is definitely unpleasant for the passenger. Consequently, if speeds on curves are to be increased so as to travel, for example, at over 87 m.p.h. on curves with a radius of 2,600 ft. and a super-elevation of 5·5 in., and journeys such as Paris-Lyons or Paris-Bordeaux are to be made at an average speed of 100 or even 112 m.p.h. without having to slow up on curves, it must be possible to avoid subjecting passengers to this centrifugal acceleration. The same problem exists for travel on cross-country lines with sharp bends.

One solution is to allow the body of the carriage to oscillate like a pendulum about a longitudinal axis placed above its centre of gravity. During an experiment made in February, 1947, on the Paris-Etampes line at 100 m.p.h. on a curve with a radius of 2,624 ft. observations made of an oscillating compartment installed inside a carriage proved that the lateral accelerations of the compartment were effectively and considerably reduced. Whereas the carriage itself was submitted to very uncomfortable accelerations of $0{\cdot}24g$, those recorded for the compartment were only one-quarter of this—$0{\cdot}06g$—which is quite admissible. The mobile compartment assumed the same inclination as the resultant of gravity and of the centrifugal force.

With such encouraging results, it was decided to put a complete carriage to the test. About 1942 the Americans experimented with a carriage called "Precopendulum" using a similar principle, but in that the inclination of the carriage was obtained by means of flexible springs and not through a true pendular suspension.

To fully solve this problem, the following questions had to be considered. Firstly, in order to travel at speed, the passenger's comfort must be improved and, secondly, the vehicle must not submit the track to excessive lateral stresses. In the present experiment an effort was made to diminish the dynamic lateral stresses by making the four wheels of the bogie independent so as to avoid any nosing of the carriage. It is thought to be possible to avoid the wear and tear arising out of the use of independent wheels by having a lightweight bogie.

With the same end in view, research was conducted towards the development of a railcar in order to avoid the use of traction by a locomotive which gives rise to lateral stresses greater than those due to a railcar. However, in the first vehicle now undergoing tests, the electric motors have not been installed, and during its first trials it is being hauled by an electric locomotive. Equivalent masses of similar weight will replace the motors.

Finally, the problem of braking, inseparable from that of speed, has led to the use of disc-brakes, allowing a better dispersion of the heat engendered. The light load per wheel—4 or 5 tonnes—reduces to a moderate level the energy dissipated when braking at 124 m.p.h.

The French Railways "pendulum" carriage is a vehicle with two bogies on which the body swings. The body is built on to a steel girder, each end of which is in the shape of a swan neck. The ends of this girder rest on raised supports which form part of the bogies. For the speeds contemplated, the body has been designed to allow an inclination of 18 deg. to right and left; its section has rounded angles and its shape is such that it can oscillate without infringing the limits of the loading gauge. The height of the longitudinal axis of oscillation is 5 ft. 9 in. above the track and it is estimated that the centre of gravity of the oscillating body will be 28 in. below this axis. The total weight of the carriage is 57 tonnes. In order not to exceed this weight, a large percentage of which is represented by the mechanical parts, the body has to be very light and is therefore constructed of a light alloy, argon-arc welded.

The carriage built for these tests can accommodate 32 passengers. Its principal dimensions are: length between bogies, 55 ft. 4 in.; length of body, 74 ft. 1 in.; and length overall, 75 ft. 1½ in. It was designed by the carriage and wagon research department, and was constructed in their workshops at Sotteville, near Rouen.

Tilted here by hand, the swinging body of the experimental coach allows curves of 2,600 ft. radius to be negotiated at 100 m.p.h. without discomfort to the passengers.

AXIAL COMPRESSOR DEVELOPMENT

Last May an exceptionally interesting lecture on the development and the changes in the philosophy of design of axial compressors was given to the Journées Internationales des Sciences Aéronautiques, "The Post War Development of the Axial Compressor in Great Britain," by Professor A. D. S. Carter, at that time on the staff of the National Gas Turbine Establishment (Mr. Carter is now professor of mechanical engineering at the Royal Military College of Science, Shrivenham). The text of the lecture has recently been published by the Office National d'Études et de Recherches Aéronautiques, 29, Avenue de la Division Leclerc, Chatillon-sur-Bagneux (Seine).

Immediately after the second World War an attitude of complete confidence controlled the outlook towards the axial compressor—it seemed that accurate estimates of performance could be made from the drawing board. The first real set-back was encountered in 1948, on the prototype Avon, when the well-known phenomenon of surging as a result of rapid acceleration was met for the first time. This problem led to a more critical review of the fundamental knowledge of flow and a more sophisticated approach, on macroscopic rather than microscopic lines. The key to solving this particular problem lay in the stage characteristics and the importance of matching them.

Although subsequently the empirical approach now dominated compressor development, fundamental work continued and probably the most significant advance here has been the evolution of the actuator disc theory which, although not used directly in design, goes a long way towards justifying some of the more empirical design methods.

More recently, the use of longer and thinner blades has led to fatigue failures arising from vibration, either self-excited or forced by cyclic variations, which may occur when blades are stalled or choked. It is now standard British practice to investigate thoroughly vibration patterns and stress levels in a prototype compressor early in its development life. Another recent problem is the influence of bad inlet distribution on surging, leading to "flame-outs"—such as occurred in certain fighter aircraft when the guns were fired, disturbing the intake flow. Changes of incidence also affect intake distribution, and are likely to have more serious effects on supersonic intakes.

To-day, those who have worked on axial compressors know that there are vast gaps in knowledge of the detail air flow—"after the first moving blade row the flow gradually becomes what can only be described as a mess. . . . Academically, the position could be described as depressing, and yet practically the outlook is bright. We can see our way clear to designing compressors of any pressure ratio likely to be required in future. We can achieve high efficiency, high stage temperature rise, high flow per unit frontal area, low weight, and even low cost if required."

Research

SHAPING A RESEARCH TEAM

When a team is engaged on a research project it is essential that it be well organised. An individual working alone can adjust his experimental technique to suit himself. But a member of a team cannot: an oversight on his part may lead to a frustrating waste of effort by his colleagues.

Vibration testing in gas turbines calls for thoughtful organisation of research. This is made clear in a paper "Developments in Methods of Measuring Stresses in Compressor and Turbine Blades on Test Bed and in Flight," by Mr. D. A. Drew, read at a recent meeting of the Institution of Mechanical Engineers. The author is in charge of the vibration department of Rolls-Royce Limited, Derby, and his outline of the organisation there is informative. It will be of interest to workers in many fields of research other than that of gas turbines.

The general problem is familiar. Strain gauge measurements on compressor blades cannot be carried out by a team of highly specialised electronic engineers because: (1) there is an insufficiency of engineers; (2) such specialised personnel would not be expected to have any considerable knowledge of the nature of vibration in a number of different components in a large variety of engines. One solution is to build up a team of specialists who can adjust themselves to their new field. On this point Mr. Drew writes: "Some experience in testing is a necessity, quite apart from a good knowledge of electronics, if the utmost is to be obtained, and the test teams are expected to make use of their experience."

Work at Rolls-Royce has emphasised the general truism that it is very important indeed that those responsible for carrying out and supervising tests should be well aware of the significance of the testing data they obtain as they are obtaining it. "Queries on the test data while the engine is on the bed are always welcome," writes the author. "They greatly stimulate the interest in the job and it is always possible to cross-check any point; it is frequently impossible or very difficult indeed to cross-check points a week later."

The arrangement of personnel that has been found to give successful results in this company is made up as follows:

(1) An engine team of four engineers responsible for the discussion and direction of the test.

(2) A strain-gauge section working under instruction from the engineers. In addition to its work on tests, this section carries out development work on strain gauges and makes types that are not commercially available.

(3) Test teams responsible respectively for running: the central recording equipment in two rooms near the laboratory; a mobile caravan equipped in much the same way as the central test room; six complete sets of measuring equipment mounted on hand trolleys; telemetry and airborne tape recording equipment; and static vibration equipment for obtaining the resonant frequencies of a wide variety of components under laboratory conditions.

(4) The analysis section that interprets photographic records in terms of stress, speed, frequency, pressure, etc., and plots the results for the team of four engineers.

LISTENING TO HYDROGEN

A maser operating successfully in the 21 cm. wavelength band has been produced at Harvard University, U.S.A. Used with radio telescopes it should extend their range by a factor of ten. It might also be used to increase the sensitivity of radar receivers. Harvard hope that the device will allow the detection of signals a thousand times weaker than those at the present limit of detection. However, it is only in the early experimental stage and has yet to be proved in service.

The Harvard three-level solid-state maser (Microwave Amplification by Stimulated Emission of Radiation) is the first to operate at the wavelength of the radio emission from interstellar hydrogen. (A description of the first solid state maser and its theory of operation was given in ENGINEERING, page 362, vol. 183, 1957.) The radio emission is of fundamental importance to radio astronomers as it enables them to map out the distribution of hydrogen in the universe.

The heart of the maser at Harvard is a single crystal of potassium cobalticyanide with an intentionally introduced impurity of 0·5 per cent. potassium chromicyanide. The crystal—about an inch long—is kept in a bath of helium at a temperature of 2 deg. K. A microwave signal generated in the laboratory pumps electrons to the highest of three energy levels in the crystal. The incoming 21 cm. radiation from an aerial excites the crystal and causes the electrons to drop to the middle energy level. In doing so they give off radiation at 21 cm. that is more intense than the incoming trigger signal. Thus the net effect is to amplify the incoming signal.

The extremely low temperature is necessary to reduce the number of spontaneous transitions from the top level. In this way the crystal is made more sensitive to the incoming signal. The actual height of the energy level and so the frequency of emission is controlled by an applied magnetic field.

The maser-equipped telescope should be able to test various cosmological theories by confirming or denying the presence of hydrogen gas between the galaxies. Funds provided by Harvard's Division of Engineering and Applied Physics under a contract with the jointe Services, paid for the development of the maser.

COMPUTING PIPE STRESSES

A programme has been developed that allows the calculation of stresses in three-dimensional pipe systems. It is for multi-anchor systems and may be used for steam or hydraulic pipe layouts in marine or industrial installations, power stations, chemical plant, and oil refineries. The programme uses the methods of pipe stress analysis developed by Mr. H. H. Gemmell of Yarrow and Company, Limited, Glasgow. List DC.27/24 gives a brief description of the programme and is available as part of the Ferranti Computing Service.

When using previous hand methods it might have taken several months to stress a three-dimensional system with three anchors, this representing something like the practical limit. More complex systems often had to be simplified by introducing further anchors that partitioned the complete system into manageable portions.

The programme has been set up for the Pegasus computer, made by Ferranti Limited, Hollinwood, Lancashire, and can deal with any multi-anchor system of pipe layout up to a maximum of nine anchors. Each branch—that is, run of piping without intermediate offshoots—is assumed to consist of a number of sections that are either straight lengths of pipe or plane circular arcs, with any orientation in space. The physical constants of the pipe may vary in any desired manner from section to section. The basis of the calculation is to assume that one of the anchors remains fixed in space, while given deflections are applied to the remaining anchors. The deflections will ordinarily consist of those due to thermal expansion reversed in sign, with allowance made for cold pull-up, etc. The programme will then compute the forces and moments that have to be applied at the free ends to produce the given deflections.

The analysis falls naturally into two parts. The first consists of the analysis of a single branch assumed fixed at one end, that is, the computation of a flexibility matrix of order six, which relates the deflections produced at the free end to the corresponding loading. (There are six components of deflection—three linear and three angular, and six components of loading—three forces and three moments). This calculation is carried out for every branch of the system.

The second part of the analysis consists of utilising the resulting flexibility matrices, multiplied by certain geometrical matrices, to build up the final flexibility matrix of order $6m$, where m is the number of free ends. Since the deflections at the free ends are given, it only remains for the computer to solve the set of $6m$ equations to give the loads that are produced at the ends.

The time taken for the performance of a calculation is very dependent on the complexity and configuration of the pipe system. They are all very short in comparison with previous methods. For example, a pipe consisting of a single branch with 20 sections would only take about 3 minutes, and it would be a very complicated system that took an hour.

SEPARATING MATERIALS BY ELECTROSTATIC CHARGES

The generation of electricity by friction and the attraction of particles to charged electrodes play an important part in many industrial processes. They form the basis of the electrostatic separation of minerals, where particles of different conductivities are separated by their different deflections on passing a charged electrode.

The electrostatic process is in its infancy but it has the advantages of operating on dry material and performing well on fines. It has been used especially in Germany for such separations as small diamonds from gangue, gypsum from marl, and zircon (a bad conductor) from rutile and ilmenite (good conductors).

Fundamental research into the mechanism whereby particles receive an electric charge has been carried out for the past few years in the Department of Chemical Engineering at University College, London. An account of the work appears in a paper by M. B. Donald, Head of the Department, in the January issue of *Research*. Most of the work was done with glass spheres between 86 and 246 microns in diameter. The charge gathered when the spheres rolled down a chute was studied.

It was found that the surface conditions of the spheres varied considerably in their electrical properties. By the appropriate treatment it was possible to produce a stable film on the glass that enabled reproducible results to be obtained from day to day, but Professor Donald remarks that "if a constant reproducible surface is required, the use of glass made into spheres is the last substance that should be considered." A second frustration was the phenomenon of drift; the charge acquired was never the same for two experiments running. There was, in fact, an ageing effect for both chute and particles, which may be due to welding associated with friction. Thus, in conclusion, the author writes "These results . . . indicate that contact electrification may only play an insignificant role in frictional electrification and that the main factor may not be interchange of ions or electrons but some micro or macroscopic transfer of material."

Continuing **Research and Development**

RADIATION FROM THE SUN *High-Altitude Research Problems*

"High-Altitude Research in the International Geophysical Year" was the subject of a lecture given before the British Interplanetary Society in London recently by Dr. R. F. L. Boyd of University College, London, who discussed the phenomena which can be observed at the high levels of the earth's atmosphere. After reviewing some of the methods which can be used at the earth's surface to determine the properties of the atmosphere, Dr. Boyd described the difficulties which attend observations of the solar spectrum.

At the ground, the atmosphere has only a narrow "window" through which visible light and the near ultra-violet and infra-red rays can pass, but at altitudes of 100 km. or more the window widens to permit all radiations from gamma rays to short radio waves to enter. When viewed in these circumstances, the sun does not behave as a black body at the temperature of the chromosphere, 6,000 deg. K: although, with infra-red light, only about one-sixth of the black-body radiation is produced, at wavelengths corresponding to the ultra-violet and X-rays the radiation is hundreds or thousands of times more intense, corresponding to a temperature of about 0·75 million deg. C. This radiation comes from the highly-excited outer atmosphere of the sun, and has only been observed since the introduction of rocket soundings.

Although the atmosphere at great heights allows wide bands of radiation to be seen, there are instrumental difficulties which have not yet been overcome: ionisation counters, which offer a most convenient method of measuring the radiations, require windows to permit the radiation to ionise the detecting gas, and at the moment all the available windows exclude the wide band, in the ultra-violet, between 50 and 1,000 Angström units. Windowless counters, which leak gas continuously, are being developed.

At Woomera, the R.A.E. Skylark rocket is giving excellent service. Recent firings have shown that the dispersion of the trajectory is very low, so that firings from Aberporth could be undertaken safely, thus probing a different section of the atmosphere. An excellent set of data from a grenade experiment (to measure the temperatures and winds in the upper atmosphere) has been obtained, and is being analysed on an electronic computer.

Production

VERSATILE PRECISION ROLLING MILL

The numerous schemes for large-scale steel production which have come into operation in recent years have tended to overshadow the efforts—no less vital to the national economy—of some of the smaller steel producers. Large integrated plants and costly mechanical equipment can only be used where high outputs of a relatively small range of products justify them, and there are some types of steel which are not required in large quantities. On the contrary, they may be wanted in small batches and a variety of sizes and specifications. In such cases the use of simpler plant is unavoidable, and the hand mill can hold its own. Nevertheless, there is no reason why the equipment should not be designed to take advantage of modern techniques. A new 10½ in. hot rolling mill just brought into service by Sanderson Brothers and Newbould Limited, Attercliffe Steelworks, Sheffield, 9, is a good example of what can be done in the application of modern methods to batch- and small-quantity steel rolling of high quality.

The mill, which is designed for a mixed rolling programme of high-speed, tool and alloy steels, including bars for bright turning, was built by the Brightside Foundry and Engineering Company, Limited, Ecclesfield, Sheffield. It is electrically driven, and of the double-duo type, with a rolling speed of 300 to 900 ft. per minute. There are five stands of rolls, with provision for installing a sixth if necessary, and it is possible to finish-roll in any of the last three. Bars up to 60 ft. long can be rolled, in sizes from ⅜ in. to 1¾ in. diameter rounds, with equivalent sections and flats.

The double-duo type of mill was chosen because of its flexibility of operation, accurate control of size, and elimination of "dead" passes; the latter point it shares with its predecessor, a normal three-high mill. The roll arrangement is simple. Viewed from the delivery side of the mill it can be seen that there are two pairs of rolls in each housing, one pair just above floor level and the other somewhat higher and towards the back of the housing. A bar enters the lower pair of rolls and is returned by the upper pair to the side of the mill from which it started. Further passes are made as required. Adjustment of the rolls is simplified by this arrangement, the wear on the rolls is equalised, and the number of passes which can be carried in one stand is increased. How versatile the mill can be is illustrated by a typical rolling. Taking a 3 in. square billet, the mill rolled it to 1⅛ in. diameter in 13 passes; ten roughing, two middle and one finish. As then set up the mill could, with only a small alteration to the guides, deal with a range of rounds from 1¼ in. to $\frac{31}{32}$ in. diameter by $\frac{1}{64}$ in. increments, 1½ in. to ¼ in. squares, and 2½ in. to ½ in. flats. Changing one or more of the roll stands would bring in further sizes. Roll changing is facilitated by the provision of spare housings, which enable two complete stands to be prepared while the mill is in operation. A Shelvoke and Drewry heavy-duty fork-lift truck is used to move completely assembled housings as required.

Each of the mill stands is equipped with cast steel chocks and roller bearings, and the top rolls and their chocks are balanced by springs and suspension bolts. Vertical adjustment of the rolls is by forged-steel screws, swivel levers and notched discs. Oil-injection couplings are used, to allow the roller bearings to be fitted, and a dust-proof maintenance shop adjoins the spare stand erection beds. Water for roll cooling is drawn by a 400 gallons per minute Worthington-Simpson pump from the nearby

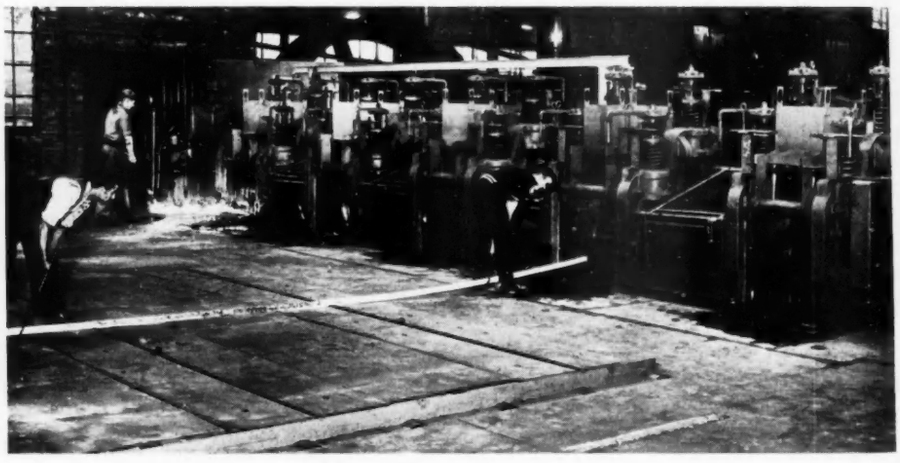


Fig. 1 Versatility and accuracy are salient features of the 10½ in. double-duo mill at Sanderson Brothers and Newbould Limited, Sheffield.

Fig. 2 The position of the balance springs on the roll housings in this view of the roughing stand shows how the rolls are arranged.

River Don, and delivered to ball-valve controlled tanks over each stand. From here the water is directed on to the rolls by flexible hose, and drained away to a scale-collecting pit.

DRIVE AND AUXILIARIES

An English Electric 500 h.p. 500 volt direct-current motor drives the mill through Brightside gearing, the speed being variable from 300 to 900 r.p.m. Current is taken from the public supply mains at 11 kV and a transformer and steel tank rectifier convert the supply to 500 volts direct current. The English Electric switchgear is housed, together with the other electrical equipment, in the motor house, but there is a control desk adjacent to the mill roughing stand so that the mill supervisor can have the speed adjusted as required during normal running.

At present billets are heated in a continuous-type pulverised-fuel fired furnace, which served the former 10 in. three-high mill, but this heating capacity is to be supplemented by a second billet furnace to be erected on the site of the steam engine drive for the old mill, as soon as the engine has been cleared away. Billets are transferred from the mill furnace to the roughing stand by a live-roller conveyor, hot shears being provided adjacent to the mill for use when required.

Since the mill will finish-roll in any one of the last three stands the final delivery point will vary, and power-operated skid transfer gear is provided in the floor, spanning the line of finishing stands, to move bars to a live-roller conveyor leading to a hot saw or shears.

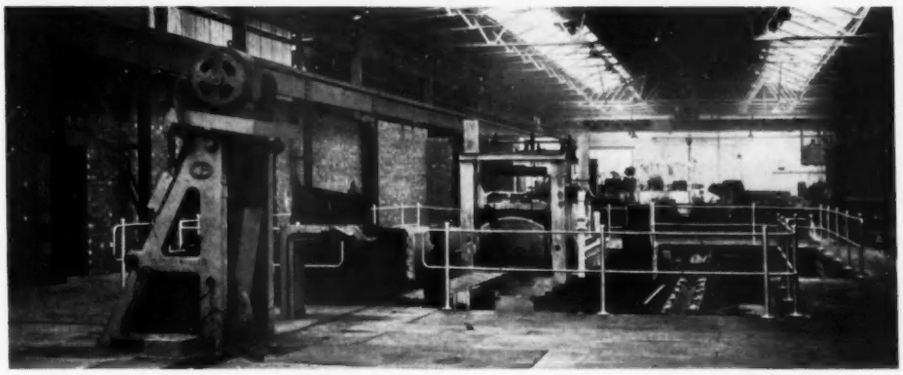


Fig. 3 On the delivery side, skid gear transfers the bars to a live-roller track, from which they pass to be sawn, sheared, slowly cooled, reeled or heat-treated as required.

Rolled material can be dealt with in several ways. After cutting to length with a Mubea shear or a Clifton and Baird hot saw (equipped with a 36 in. Sanderson blade), bars pass to a short live-roller table. Those products not requiring further treatment pass to a straightening rack, from which they are removed by an overhead electric travelling crane. Alternatively, the material can be reeled on a Platt hot reeler, before passing to a further rack, ready for disposal. Bars requiring slow cooling are charged into a town-gas fired furnace at the end of the live-roller track, or else into a nest of slow-cooling tubes. The mill finishing section adjoins the works heat-treatment shop, and rolled products for hardening and tempering, normalising or annealing can be placed by the overhead crane on tables from which they can be picked up by a revolving-type charging machine which serves the heat-treatment furnaces.

GETTING READY TO PRODUCE MORE ELECTRICITY

The Central Electricity Authority, which surrendered its powers to the new Electricity Council and Central Electricity Generating Board on New Year's Eve, retired in an atmosphere not entirely untinged with gloom. In what was probably its last public announcement, the C.E.A. revealed last week that the investment squeeze will now affect its programme of expansion which was to have increased electricity supply to some 40,000 MW in 1965, compared with 22,500 MW in 1957. The general lines of the programme, which was to have cost £3,000 million, will be retained, but future outlay must be spread not over eight years, but over nine or ten. It has been estimated that the expenditure envisaged up to 1965 will in effect be cut by between 10 and 20 per cent. This will modify expansion of both conventional and nuclear power station construction and the provision of overhead power lines and ancillary distribution equipment.

In some respects there is no cause for immediate concern over this latest announcement. The C.E.A., when the plan was first mooted, thought that demand for electricity would continue to expand by about 9 per cent. per annum —the average rate of increase over the past ten years. In fact the curve of expansion has flattened slightly since 1955 with the check in general industrial expansion. The effect of this check on electricity requirements was in part offset by a sharp increase in demand engendered by the expansion of rural electricity supplies. In 1956/57, for example, sales of electricity to farms rose by 18 per cent., compared with an overall increase in demand of less than 7 per cent. The expansion programme in rural electricity supply is now virtually complete, and overall demand is likely to expand at a slower pace (if no worse) as the effects of the credit squeeze on industrial demand become more apparent. In this respect, therefore, the latest capital cuts on electricity are merely an extension of the credit squeeze, and there is no great likelihood of any shortage in electricity supplies resulting from the intended reduction in capital expenditure.

There will be a large, and somewhat misleading, cut in new capacity available this year and next. The 2,000 MW of new generating capacity planned for the year 1958/59, for example, will be cut to 1,200 MW, while in the same financial year expenditure by the new Central Electricity Generating Board is planned to increase by only 3½ per cent. to £245 million, compared with an increase in the current financial year of 15 per cent. over 1956/57. But unless further capital cuts are demanded, average capital outlay for the revised duration of the scheme will rise from 1959/60 onwards to well over £300 million per annum. It is to be hoped that there will be no further reductions in capital outlay on the generation and supply of electricity to British industry. If the Free Trade Area proposals come to anything, the expansion of trade could mean a sharp increase in industrial demand for electricity after 1959. The new electricity authorities should be fully prepared to meet this —even to the extent of raising tariffs now if this is necessary to maintain capital investment in the future.

MORE MAIN-LINE DIESELS

A contract was placed a week ago for a further 45 main-line Diesel locomotives. Following the order for 52 Diesel hydraulic locomotives from North British this is the second major order for main-line locomotives to be announced within a month or so. The latest order, for 1,550 h.p. Diesel-electric locomotives, was placed with the Birmingham Railway Carriage and Wagon Company. The locomotives will be equipped with Sulzer Diesel engines and Crompton Parkinson electrical equipment. The total value of the order is about £3 million.

The locomotives are intended for use on the Southern Region's Kent Coast lines, which are due to be electrified, and will mainly be used for hauling freight traffic and for inter-regional passenger services which cannot be operated by electric multiple-unit trains or electric locomotives.

The original modernisation plan for British Railways called for the construction of 2,500 main-line Diesel locomotives by 1970. It was, however, recently announced by the Minister of Transport that some delay would be necessary in carrying out the modernisation programme and that it would not be possible to go forward with the programme for main-line Diesel locomotives as fast as had been hoped. It is possible, therefore, that the figure of 2,500 Diesels will be cut as it becomes more feasible to proceed, in some cases, directly to electrification. On the other hand, the full effect of main-line electrification must necessarily take several years to be felt, though it appears likely that the electrification programme will go forward as planned, and with no new steam locomotives being built the Diesel building programme cannot be cut too substantially. Whatever the final level of orders, however, those already placed, mainly for the pilot programme and for delivery by the end of 1958, will ensure a steadily rising volume of production for the next year.

PRE-FINISHING PROCESS FOR CASTINGS

A chromate oxidisation process, or C.O.P., for the treatment of aluminium castings and their coating with an insoluble granular aluminium oxide layer, has been installed by Woods of Colchester Limited, an associate company of the General Electric Company Limited, Magnet House, Kingsway, London, W.C.2. The plant consists of three tanks; the first holds 1,000 gallons of the chromate solution, the second is a running cold-water rinse of 500 gallons capacity, and the third, also of 500 gallons capacity, is a hot-water rinse. Some 13 tons of impellers, motor carcasses, end covers and other aluminium components, in the form of gravity, pressure, and sand castings, and sheet aluminium components are now treated during a 44-hour week. The result has been a cut in production costs and better products, for the treatment provides greater resistance to corrosion and a better bond for finishing paints than the paints, lacquers and other materials previously used.

The plant has been designed by the Jenolizing Company Limited, 13 Rathbone-street, London, W.1, in co-operation with the firm's engineers.

Engineering at Home

WINDOW TESTING

Windows are an important part of most houses. Because of this their performance has been studied in some detail by the Building Research Division of the National Research Council of Canada. The division regard the work as important. It has dominated the work their cold room has been put to since it was completed in 1955.

For this work, a partition consisting of wall constructions into which the windows are fitted divides the room. One side is then held at normal inside temperature and humidity while the other is subjected to temperatures ranging down to − 40 deg. F. Observation can be made of window surface conditions, temperatures, and condensation under different conditions of exposure. The room has been used in this way on exploratory studies of the performance of sealed double-glazed window units. An extension of the study is planned. Tests have also been carried out on prototypes of another assembly in which thermal breaks were incorporated in the metal frame. For such studies apparatus was assembled to measure air infiltration characteristics of the windows.

Another study has been concerned with the formation of condensation between the panes of double windows not of the factory-sealed type. Venting of the space between panes to the outside is being investigated as a means of preventing condensation.

Apparatus is now being completed for use in association with the cold room to measure the heat losses of building sections, including windows. The thermal performance of a window is affected by the surrounding construction to a degree depending on the arrangement of the materials. This can greatly complicate the heat flow and condensation tests since it is necessary to fit windows into a construction that duplicates, at least thermally, the construction with which the window will be used.

From the user's point of view, the standards required for the performance of windows are generally the same whether the window frames are made of wood, steel, or aluminium. And the need for standard methods for testing windows in general has become urgent in Canada. As a first step, a meeting was held recently at the Building Research Centre, Ottawa, to discuss all aspects of window testing. It was held under the auspices of Committee E-6 of the American Society for Testing Materials.

THERMAL BARRIER

Considerable reduction can be achieved in the heating bill for a house by careful thermal insulation. In general, this can most profitably and easily be carried out in the attic. Insulating materials are available that can be layed with relative ease and taken up when desired.

The third issue of *Shoppers Guide* considers possible thermal insulants under four headings: a blanket of glass fibre or mineral wool; loose wool-glass or mineral; granules of vermiculite; and aluminium foil. All are good insulants but the first two are best. The only significant variation between brands of any one type is price. The type chosen depends on which is most convenient to lay in any particular attic.

Aluminium foil's greatest merit is its lack of bulk. It is easy and clean to handle and easy to cut to shape. A recent publication *Thermal Resistance of Airspaces and Fibrous Insulations Bounded by Reflective Surfaces*, by H. E. Robinson, L. A. Cosgrove, and F. J. Powell, sets out to give quantitative values for the advantages of using aluminium foil. The study shows that air spaces in buildings give better insulation if they are surfaced on one side or sub-divided with highly reflective surfaces. In addition, the use of reflecting surfaces on typically fibrous insulating materials, of blanket, batt, or board form installed with adjoining air spaces, materially increase their insulating effect, especially where the direction of heat flow is downward.

The heat transfer measurements were made on test panels in a rotatable, guarded hot-box apparatus. The test procedure and equipment are described in the report. The results are presented in terms of thermal resistance. An appendix gives the method of calculating air-space conductances, and lists the range of experimental conditions at which the conduction-convection coefficients were obtained.

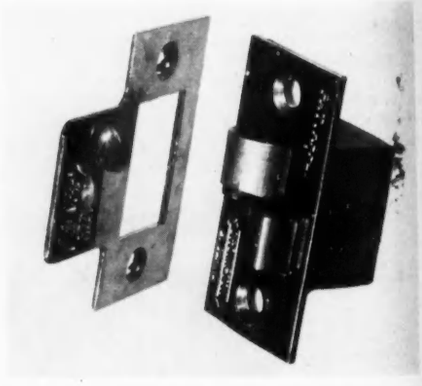
Another use for aluminium as an insulant is in fabrics. Deering, Milliken and Company, Incorporated, are producing metal insulated linings for coats. The linings are claimed to keep you warmer in cold weather, cooler in the hot sun, and to make cloth hang better. They are also claimed to be porous.

TWO-LEVER DOOR CATCH

A door catch designed to get rid of door rattle is being made by Thomas Crompton and Sons Limited, Ashton-in-Makerfield, Cumberland. It is called the Weaver catch. As will be seen from the illustration, the main operating parts are two opposing quadrant lever members. These are forced outwards by torsion springs and so occupy the maximum space available in the aperture of the striking plate.

The two lever members are transversely mounted in the catch in such a manner that a link can be assembled with them. One end of the link is inserted in a hole drilled in the upper end of one member, the other end in a hole drilled in the lower end of the second member. In this way, pivotal movement of either member causes corresponding movement in the other. The inner legs of the torsion springs that force the lever members outwards bear on their underside; the outer legs bear on the case of the catch.

As the door closes the nearest lever member meets the striking plate and pivots inwards into the body of the catch, the opposing member doing likewise. The motion continues until the members are almost in vertical alignment with one another. Further movement of the door permits the first lever member to register with the aperture in the striking plate, but it is unable to enter until the second lever does so. Immediately the latter registers with the aperture both members enter. They are then able to spring apart under the action of the torsion springs and hold the door firmly in the closed position, free from rattle. When the door is opened the operation is virtually the reverse.



The two lever members of the door catch occupy the maximum space available in the striking plate.

POLYMETHYL METHACRYLATE BATH

Last August marked the 21st birthday of Perspex. For it was in 1932 that a patent was filed for the acetone cyanohydrin process that forms the basis for the commercial manufacture of polymethyl methacrylate sheet, known more familiarly as Perspex. In 1946 a colouring process was introduced. Now Imperial Chemical Industries Limited produce 11,000 tons per year.

The lighting industry is the main user, but the material finds a wide variety of other applications. One is the Perspex bath, produced by Thermo-Plastics Limited, Dunstable, Bedfordshire. The light weight of such a bath (40 lb.) makes it easy to install, and the heat loss associated with a cast-iron bath does not occur. Another advantage is the absence of any surface coating to chip or wear. The bath is produced in opal or pastel shades and normal plumbing fixtures can be attached to it. The overall length is 5 ft. 6 in.

The bath is made up of $\frac{3}{8}$ in. Perspex material and is produced by physical moulding, vacuum assisted. To find out how the bath wore with prolonged cleaning, the firm carried out accelerated tests with various materials. As a result they say that cleaning is best carried out with soapy water or a detergent. Abrasives such as are used on the familiar vitreous enamel bath are not recommended. The maximum temperature for the material is between 100 and 110 deg. C. if the bath is used in the normal way there is little chance of damage by overheating. The minimum temperature the bath should be subjected to is about − 5 deg. C.

Thermo-Plastics use the same material for other items, such as sink units. In addition, their laboratories are developing a new range of reinforced glass-fibre sink and draining-board units. The chief problem is to develop a surface that is hard enough to withstand rough treatment. The difficulty will probably be overcome by the use of a hardening substance added to the resin.

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